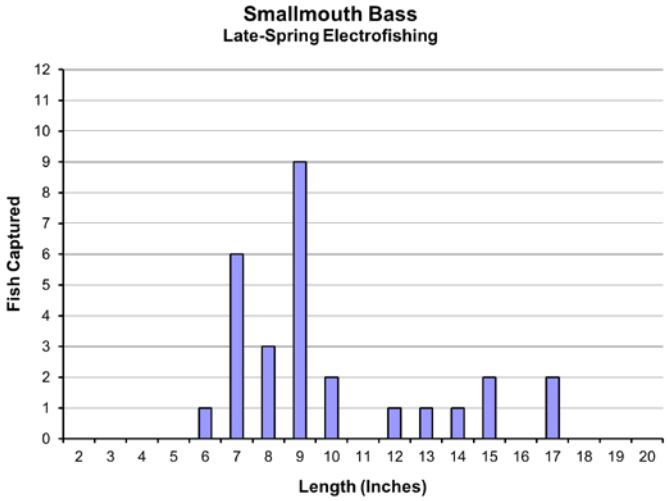
Appendix A: WDNR 2012 Spring Netting Survey and Walleye Population Estimates

Late-Spring Electrofishing Survey Summary
Sand Lake, Sawyer County, 2012

The Hayward DNR Fisheries Management Team conducted an electrofishing survey on Sand Lake on June 5 as part of our baseline monitoring program. A total of 4 miles of shoreline was sampled (1 mile sub-sampled for panfish). Primary target species were smallmouth bass, largemouth bass, and bluegill. We also obtained useful data on the status of juvenile walleye. Quality, preferred, and memorable sizes referenced in this summary are based on standard proportions of world record lengths developed for each species by the American Fisheries Society.

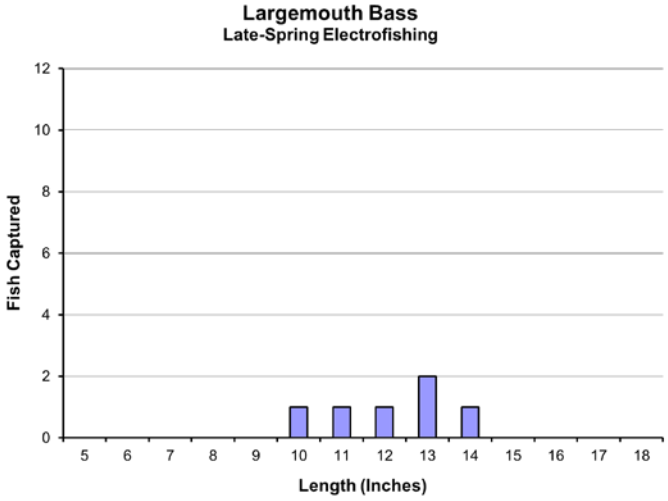
Smallmouth Bass

Captured 7 per mile ≥ 7”	
Quality Size ≥ 11”	26%
Preferred Size ≥ 14”	19%
Memorable Size ≥ 17”	7%


Smallmouth Bass
Late-Spring Electrofishing
Fish Captured
0 1 2 3 4 5 6 7 8 9 10 11 12
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Length (Inches)

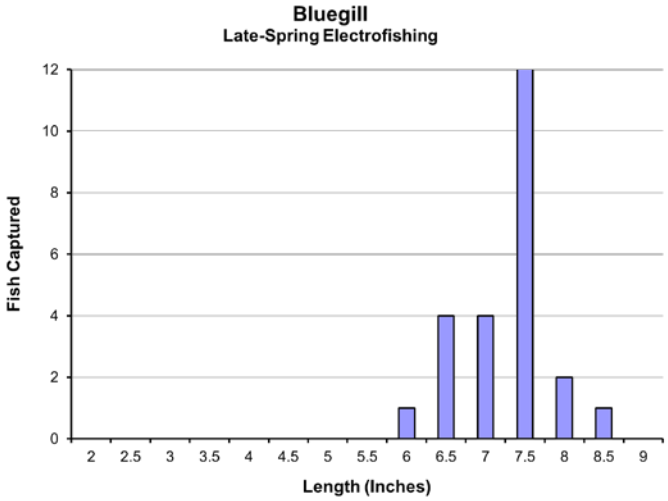
Largemouth Bass

Captured 2 per mile ≥ 8”	
Quality Size ≥ 12”	67%
Preferred Size ≥ 15”	0%



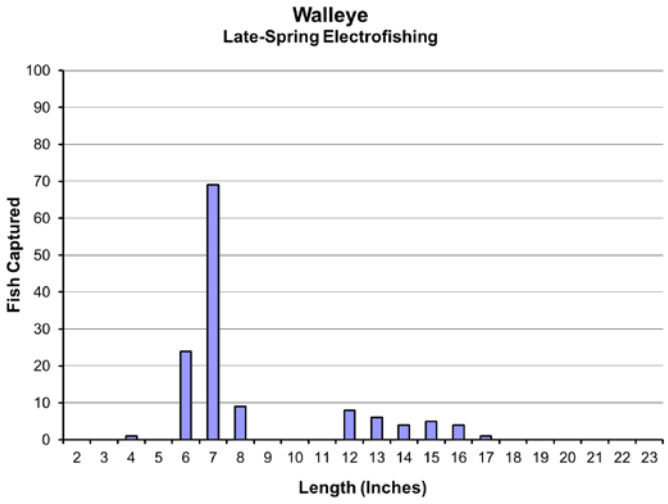
Bluegill

Captured 25 per mile ≥ 3”	
“Keeper” Size ≥ 7”	80%
Preferred Size ≥ 8”	12%



Walleye

Captured 26 per mile <10 ”



Summary of Results

Water temperature at the time of this survey was 66°F, appropriate for sampling spawning bass and pre-spawn bluegill. Electrofishing effort was spread throughout the lake and covered a variety of habitat types. The north side of the lake had predominantly sandy substrate with little woody or vegetative cover; considerably fewer fish were sampled there than on the south side of the lake, which had more stumps and aquatic vegetation.

Smallmouth bass were found in relatively low numbers, possibly because predation by abundant walleye is very efficient in lakes with few areas of rock cobble where young smallmouth bass prefer to hide. The smallmouth population was dominated by smaller individuals. Growth rate and maximum size of smallmouth in Sand Lake are likely limited by the prey base. Smallmouth bass prefer to eat crayfish, which do not seem abundant in Sand Lake due to a scarcity of rocky substrate.

Largemouth bass were found in trace numbers. While many other lakes in the area have experienced a decrease in walleye abundance concurrent with an increase in largemouth bass abundance, Sand Lake has remained a walleye-dominant system. Because of their abundance and effectiveness as predators, walleye are likely limiting natural recruitment of both bass species as well as panfish – a pattern that has been observed in other area lakes with deep, clear water and few aquatic plants.

Bluegills were found in low numbers with a relatively high proportion of keeper-size fish. The fast growth that appears to be present in the population is likely made possible by the presence of a dense walleye population that continually thins the number of small bluegill, preventing "stunting" from occurring. The relatively low population of keeper-size fish renders this population vulnerable to angler over-harvest under a liberal daily bag limit of 25 panfish.

We also sampled many young walleyes 6 to 8 inches long. These fish were just over one year old, providing evidence of strong natural reproduction of walleye in 2011 at Sand Lake, which has not been stocked since the restoration project was completed.

Report by Max Wolter – Fisheries Biologist, Sawyer County
Data compiled by Scott Braden – LTE Fisheries Technician
Reviewed by Approved by Dave Neuswanger – Fisheries Supervisor, Hayward Field Unit

2012 Spring Netting Summary- Sand Lake, Sawyer County

Fisheries Research, Spooner

Background: Sound management of muskellunge fisheries requires clear understanding of growth rates and mortality, factors that determine population size structure. Of particular interest to managers and anglers is the relation between harvest regulations and growth potential. Size limits for trophy muskellunge fisheries should be set at levels that allow harvest of trophy fish but limit exploitation and mortality at smaller sizes, allowing fish to achieve their full growth potential. Traditional methods of aging fish include reading patterns of annuli from scales or cleithra (bones located in the pectoral girdle). Scales allow reasonable age estimation in younger fish but accuracy diminishes with increasing age. Aging based on cleithra relies on lethal sampling, which restricts samples to voluntary returns from harvested fish, or fish sampled for purposes such as contaminant sampling. Because age and growth records of muskellunge are generally characterized by small sample sizes and are variable among lakes, population modeling often relies on assumptions about growth and mortality that cannot be validated with reliable empirical data. Therefore, we are evaluating alternative methods for determining lake-specific growth rates of muskellunge in a set of study lakes, including Sand Lake.

The study is being conducted within lakes that are stocked by WDNR, and currently assumed to have negligible natural reproduction. Stocked fingerlings will be given passive integrated transponder, or PIT tags. These are small tags that produce a unique signal that can identify individual fish throughout their lives. These tags will allow the tracking of known-age fish throughout their lives, so that future sampling efforts will produce accurate records of age and growth. As the fish grow and mature, we can produce larger samples of accurately aged fish, and improve estimates of longevity and growth potential. We can also produce better estimates of survival rates of stocked fish, and infer the contribution of natural reproduction. This information improves understanding of muskellunge biology and management.

The study will also track adult muskellunge density by conducting population estimates with spring netting surveys. Population estimates require two consecutive years of fyke net surveys. Fish netted during the first year are usually marked with a fin clip, although the marking technique used in this study is tagging with a passive integrated transponder (PIT tag). The ratio of marked to unmarked fish during sampling conducted the second year is used to estimate the total adult population. PIT tags will allow us to identify individual fish and track growth from the

time of capture. However, the primary objective of adult sampling is to estimate density, a factor known to be important to growth rates.

The current study plans call for stocking 5 year classes of PIT tagged fingerlings in alternate years, and two mark-recapture adult population estimates. Sand Lake was stocked with PIT tagged fingerlings during 2009 and 2011. The project will be evaluated for cost-effectiveness based on survival rates of stocked fish after 10 years, and will be continued if survival rates are sufficiently high and funding and staffing are available.

Methods: Adult muskellunge were sampled with fyke nets. Nets were fished overnight and checked daily throughout the sample period. Muskellunge were measured (total length, inches) and tagged with a PIT tag, which provides a unique code to identify the fish. Muskellunge were released after handling. Walleye were measured and released. Walleye length data were provided to GLIFWC to supplement their walleye population estimate, but are not reported here. Baseline monitoring data were also collected for two days and provided to Upper Chippewa Basin biologists, but are not reported here.

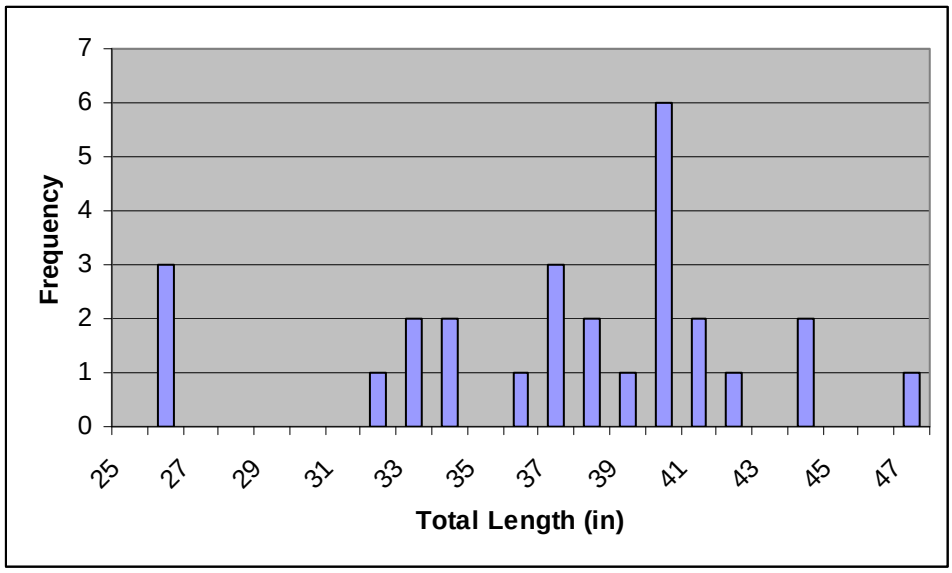
Sample locations were based on habitat and records from previous WDNR surveys. Nets were set after ice-out, beginning 3/23. Nets were moved or removed based on observed trends in catch rates and water temperature, with the last nets removed on 4/4.

Results and discussion: Twenty-seven muskellunge with total length >20" were handled during 72 net lifts, for an average of 0.37 fish/net lift, which is nearly identical to the catch rate of 0.35/net lift observed during 2011. Overall, the average length of adult muskellunge sampled was 36.8 inches total length, which is not significantly different than the mean of 36.9 observed during 2011. Size distribution is shown in Figure 1. Seven fish 40 inches or larger were sampled.

An early ice out followed by cool weather made for another unusual spring netting season during 2012 Catch rates were lower than expected, with a small number of fish marked during 2011 recaptured during 2012. The estimated population using a modified Peterson estimate was 185 ± 137. The wide 95% confidence limits are the result of the small recapture sample. The estimate of 0.20 adult muskellunge per acre (185 fish/928 acres) is below the statewide average, which is about 0.33 fish per acre, but is not unusually low. Lakes with moderate to low densities of muskellunge generally support higher growth rates than high density musky lakes.

Several juvenile muskellunge were observed in fyke nets during 2012. Most of the juvenile muskellunge contained PIT tags, which allowed calculation of growth from the time they were stocked (September, 2011) until spring. The mean growth increment was 1.54" total length. Most of the growth probably occurred during fall 2011. The growth of the fish indicates that they were in good condition at the time of stocking. Four untagged individuals were examined for evidence of tag loss. The tagged fish ranged in size from 12.1" TL to 14.0" TL. One untagged individual was slightly larger than the tagged individuals (15.1), had no evidence of scarring from a tag, and was likely the product of natural reproduction during 2010. Another untagged fish was smaller (10.5" TL), also lacked evidence of tagging, and was likely the product of natural recruitment during 2011. These fish provide evidence that limited natural recruitment is occurring in Sand Lake.

Figure 1. Length (total length, inches) frequency distribution of muskellunge >20" TL sampled in Sand Lake, Sawyer County WI during spring 2012.



SPRING ADULT WALLEYE POPULATION ESTIMATE

LAKE: SAND L — AREA: 928
COUNTY: SAWYER — RECRUITMENT CODE: C-ST
YEAR: 2012 — AGENCY: GLIFWC

POPULATION ESTIMATE SUMMARIES

COMBINED SEXES AND UNKNOWNS 15 INCHES AND GREATER

LENGTH INTERVAL (INCHES)	TOTAL GIVEN MARK	MARKED FISH SPEARED BEFORE RECAPTURE SURVEY	ADJUSTED NUMBER MARKED (M)	TOTAL CAUGHT IN RECAPTURE SURVEY (C)	UNMARKED FISH CAUGHT IN RECAPTURE SURVEY	MARKED FISH CAUGHT IN RECAPTURE SURVEY (R)	POPULATION ESTIMATE BEFORE SPEARING ADJUSTMENT	TOTAL FISH SPEARED BEFORE RECAPTURE SURVEY	POPULATION ESTIMATE (N)	STANDARD DEVIATION
0 - 11.9	120	0	120	12	6	6	225	0	225	54
12 - 14.9	1,931	2	1,929	222	145	77	5,518	39	5,557	501
15 - 19.9	617	3	614	52	37	15	2,037	17	2,054	413
20 +	12	0	12	0	0	0	13	1	14	0
TOTAL:	2,680	5	2,675	286	188	98	7,793	57	7,850	651

POPULATION ESTIMATE: 7,850 — STANDARD DEVIATION: 651
WALLEYE/ACRE: 8.46 — COEFF. OF VARIATION: 8.29%

MALES

LENGTH INTERVAL (INCHES)	TOTAL GIVEN MARK	MARKED FISH SPEARED BEFORE RECAPTURE SURVEY	ADJUSTED NUMBER MARKED (M)	TOTAL CAUGHT IN RECAPTURE SURVEY (C)	UNMARKED FISH CAUGHT IN RECAPTURE SURVEY	MARKED FISH CAUGHT IN RECAPTURE SURVEY (R)	POPULATION ESTIMATE BEFORE SPEARING ADJUSTMENT	TOTAL FISH SPEARED BEFORE RECAPTURE SURVEY	POPULATION ESTIMATE (N)	STANDARD DEVIATION
0 - 11.9	120	0	120	12	6	6	225	0	225	54
12 - 14.9	1893	2	1891	220	144	76	5,430	39	5,469	496
15 - 19.9	397	3	394	38	27	11	1,284	14	1,298	296
20 +	0	0	0	0	0	0	1	0	1	0
TOTAL:	2,410	5	2,405	270	177	93	6,940	53	6,993	581

POPULATION ESTIMATE: 6,993 — STANDARD DEVIATION: 581
WALLEYE/ACRE: 7.54 — COEFF. OF VARIATION: 8.30%

FEMALES

LENGTH INTERVAL (INCHES)	TOTAL GIVEN MARK	MARKED FISH SPEARED BEFORE RECAPTURE SURVEY	ADJUSTED NUMBER MARKED (M)	TOTAL CAUGHT IN RECAPTURE SURVEY (C)	UNMARKED FISH CAUGHT IN RECAPTURE SURVEY	MARKED FISH CAUGHT IN RECAPTURE SURVEY (R)	POPULATION ESTIMATE BEFORE SPEARING ADJUSTMENT	TOTAL FISH SPEARED BEFORE RECAPTURE SURVEY	POPULATION ESTIMATE (N)	STANDARD DEVIATION
0 - 11.9	0	0	0	0	0	0	1	0	1	0
12 - 14.9	38	0	38	2	1	1	59	0	59	20
15 - 19.9	175	0	175	14	10	4	528	3	531	176
20 +	9	0	9	0	0	0	10	1	11	0
TOTAL:	222	0	222	16	11	5	598	4	602	177

POPULATION ESTIMATE: 602 — STANDARD DEVIATION: 177
WALLEYE/ACRE: 0.65 — COEFF. OF VARIATION: 29.44%

UNKNOWNS

LENGTH INTERVAL (INCHES)	TOTAL GIVEN MARK	MARKED FISH SPEARED BEFORE RECAPTURE SURVEY	ADJUSTED NUMBER MARKED (M)	TOTAL CAUGHT IN RECAPTURE SURVEY (C)	UNMARKED FISH CAUGHT IN RECAPTURE SURVEY	MARKED FISH CAUGHT IN RECAPTURE SURVEY (R)	TOTAL FISH SPEARED BEFORE RECAPTURE SURVEY
0 - 11.9	10	0	10	0	0	0	0
12 - 14.9	62	1	61	0	0	0	2
15 - 19.9	45	0	45	0	0	0	0
20 +	3	0	3	0	0	0	0
TOTAL:	120	1	119	0	0	0	2

SAMPLING SUMMARY

	MARKING SURVEYS	RECAPTURE SURVEY
DATES:	3/23-4/1/2012	4/2/2012
GEAR USED:	E/F	E
FIN CLIP:	TC	TC
TAGS:		

REPORT PRINT DATE: 7/16/2012

LAKE: SAND L AREA: 928
COUNTY: SAWYER RECRUITMENT CODE: C-ST
YEAR: 2012 AGENCY: GLIFWC

WALLEYE LENGTH FREQUENCY

LENGTH INTERVAL (INCHES)			MARKING PERIOD: MARKED			RECAP PERIOD: UNMARKED			RECAP PERIOD: RECAPS		
			MALE	FEMALE	UNKNOWN	MALE	FEMALE	UNKNOWN	MALE	FEMALE	UNKNOWN
5.0	-	5.49	0	0	0	0	0	0	0	0	0
5.5	-	5.99	0	0	0	0	0	0	0	0	0
6.0	-	6.49	0	0	0	0	0	0	0	0	0
6.5	-	6.99	0	0	0	0	0	0	0	0	0
7.0	-	7.49	0	0	0	0	0	0	0	0	0
7.5	-	7.99	0	0	0	0	0	0	0	0	0
8.0	-	8.49	0	0	0	0	0	0	0	0	0
8.5	-	8.99	0	0	0	0	0	0	0	0	0
9.0	-	9.49	0	0	0	0	0	0	0	0	0
9.5	-	9.99	0	0	0	0	0	0	0	0	0
10.0	-	10.49	3	0	0	0	0	0	0	0	0
10.5	-	10.99	3	0	0	2	0	0	0	0	0
11.0	-	11.49	24	0	1	0	0	0	0	0	0
11.5	-	11.99	90	0	9	4	0	0	6	0	0
12.0	-	12.49	279	0	9	15	0	0	6	0	0
12.5	-	12.99	389	1	13	42	0	0	22	0	0
13.0	-	13.49	418	1	16	34	0	0	14	0	0
13.5	-	13.99	297	5	5	19	0	0	13	0	0
14.0	-	14.49	271	10	5	19	0	0	12	0	0
14.5	-	14.99	239	21	14	15	1	0	9	1	0
15.0	-	15.49	199	33	13	12	0	0	10	1	0
15.5	-	15.99	106	32	14	10	4	0	1	0	0
16.0	-	16.49	57	41	10	2	3	0	0	0	0
16.5	-	16.99	18	23	4	2	0	0	0	0	0
17.0	-	17.49	10	21	2	1	1	0	0	2	0
17.5	-	17.99	5	15	0	0	1	0	0	0	0
18.0	-	18.49	2	6	0	0	0	0	0	1	0
18.5	-	18.99	0	3	1	0	0	0	0	0	0
19.0	-	19.49	0	1	0	0	1	0	0	0	0
19.5	-	19.99	0	0	1	0	0	0	0	0	0
20.0	-	20.49	0	0	0	0	0	0	0	0	0
20.5	-	20.99	0	1	0	0	0	0	0	0	0
21.0	-	21.49	0	3	0	0	0	0	0	0	0
21.5	-	21.99	0	1	0	0	0	0	0	0	0
22.0	-	22.49	0	0	0	0	0	0	0	0	0
22.5	-	22.99	0	0	0	0	0	0	0	0	0
23.0	-	23.49	0	1	0	0	0	0	0	0	0
23.5	-	23.99	0	1	0	0	0	0	0	0	0
24.0	-	24.49	0	0	1	0	0	0	0	0	0
24.5	-	24.99	0	0	0	0	0	0	0	0	0
25.0	-	25.49	0	0	1	0	0	0	0	0	0
25.5	-	25.99	0	0	0	0	0	0	0	0	0
26.0	-	26.49	0	0	1	0	0	0	0	0	0
26.5	-	26.99	0	1	0	0	0	0	0	0	0
27.0	-	27.49	0	0	0	0	0	0	0	0	0
27.5	-	27.99	0	0	0	0	0	0	0	0	0
28.0	-	28.49	0	1	0	0	0	0	0	0	0
28.5	-	28.99	0	0	0	0	0	0	0	0	0
29.0	-	29.49	0	0	0	0	0	0	0	0	0
29.5	-	29.99	0	0	0	0	0	0	0	0	0
30.0	-	30.49	0	0	0	0	0	0	0	0	0
30.5	-	30.99	0	0	0	0	0	0	0	0	0
31.0	-	31.49	0	0	0	0	0	0	0	0	0
31.5	-	31.99	0	0	0	0	0	0	0	0	0
		TOTAL:	2410	222	120	177	11	0	93	5	0

LAKE: SAND L | AREA: 928
COUNTY: SAWYER | RECRUITMENT CODE: C-ST
YEAR: 2012 | AGENCY: GLIFWC

LENGTH FREQUENCY OF SPEARED WALLEYE

BEFORE RECAPTURE SURVEY | SPEARING DATES: 3/29/2012 | SPEARING ADJUSTMENT USED? YES

LENGTH INTERVAL (INCHES)	UNMARKED			MARKED			TOTAL			
	MALE	FEMALE	UNKNOWN	MALE	FEMALE	UNKNOWN	MALE	FEMALE	UNKNOWN	TOTAL
5.0 - 5.99	0	0	0	0	0	0	0	0	0	0
6.0 - 6.99	0	0	0	0	0	0	0	0	0	0
7.0 - 7.99	0	0	0	0	0	0	0	0	0	0
8.0 - 8.99	0	0	0	0	0	0	0	0	0	0
9.0 - 9.99	0	0	0	0	0	0	0	0	0	0
10.0 - 10.99	0	0	0	0	0	0	0	0	0	0
11.0 - 11.99	0	0	0	0	0	0	0	0	0	0
12.0 - 12.99	11	0	0	0	0	0	11	0	0	11
13.0 - 13.99	8	0	0	2	0	0	10	0	0	10
14.0 - 14.99	18	0	1	0	0	1	18	0	2	20
15.0 - 15.99	10	1	0	2	0	0	12	1	0	13
16.0 - 16.99	1	2	0	1	0	0	2	2	0	4
17.0 - 17.99	0	0	0	0	0	0	0	0	0	0
18.0 - 18.99	0	0	0	0	0	0	0	0	0	0
19.0 - 19.99	0	0	0	0	0	0	0	0	0	0
20.0 - 20.99	0	0	0	0	0	0	0	0	0	0
21.0 - 21.99	0	0	0	0	0	0	0	0	0	0
22.0 - 22.99	0	0	0	0	0	0	0	0	0	0
23.0 - 23.99	0	1	0	0	0	0	0	1	0	1
24.0 - 24.99	0	0	0	0	0	0	0	0	0	0
25.0 - 25.99	0	0	0	0	0	0	0	0	0	0
26.0 - 26.99	0	0	0	0	0	0	0	0	0	0
27.0 - 27.99	0	0	0	0	0	0	0	0	0	0
28.0 - 28.99	0	0	0	0	0	0	0	0	0	0
29.0 - 29.99	0	0	0	0	0	0	0	0	0	0
30.0 - 30.99	0	0	0	0	0	0	0	0	0	0
31.0 - 31.99	0	0	0	0	0	0	0	0	0	0
TOTAL:	48	4	1	5	0	1	53	4	2	59

AFTER RECAPTURE SURVEY | SPEARING DATES:

LENGTH INTERVAL (INCHES)	UNMARKED			MARKED			TOTAL			
	MALE	FEMALE	UNKNOWN	MALE	FEMALE	UNKNOWN	MALE	FEMALE	UNKNOWN	TOTAL
5.0 - 5.99	0	0	0	0	0	0	0	0	0	0
6.0 - 6.99	0	0	0	0	0	0	0	0	0	0
7.0 - 7.99	0	0	0	0	0	0	0	0	0	0
8.0 - 8.99	0	0	0	0	0	0	0	0	0	0
9.0 - 9.99	0	0	0	0	0	0	0	0	0	0
10.0 - 10.99	0	0	0	0	0	0	0	0	0	0
11.0 - 11.99	0	0	0	0	0	0	0	0	0	0
12.0 - 12.99	0	0	0	0	0	0	0	0	0	0
13.0 - 13.99	0	0	0	0	0	0	0	0	0	0
14.0 - 14.99	0	0	0	0	0	0	0	0	0	0
15.0 - 15.99	0	0	0	0	0	0	0	0	0	0
16.0 - 16.99	0	0	0	0	0	0	0	0	0	0
17.0 - 17.99	0	0	0	0	0	0	0	0	0	0
18.0 - 18.99	0	0	0	0	0	0	0	0	0	0
19.0 - 19.99	0	0	0	0	0	0	0	0	0	0
20.0 - 20.99	0	0	0	0	0	0	0	0	0	0
21.0 - 21.99	0	0	0	0	0	0	0	0	0	0
22.0 - 22.99	0	0	0	0	0	0	0	0	0	0
23.0 - 23.99	0	0	0	0	0	0	0	0	0	0
24.0 - 24.99	0	0	0	0	0	0	0	0	0	0
25.0 - 25.99	0	0	0	0	0	0	0	0	0	0
26.0 - 26.99	0	0	0	0	0	0	0	0	0	0
27.0 - 27.99	0	0	0	0	0	0	0	0	0	0
28.0 - 28.99	0	0	0	0	0	0	0	0	0	0
29.0 - 29.99	0	0	0	0	0	0	0	0	0	0
30.0 - 30.99	0	0	0	0	0	0	0	0	0	0
31.0 - 31.99	0	0	0	0	0	0	0	0	0	0
TOTAL:	0	0	0	0	0	0	0	0	0	0

LAKE: SAND L	AREA: 928
COUNTY: SAWYER	RECRUITMENT CODE: C-ST
YEAR: 2012	AGENCY: GLIFWC

SPAWNING POPULATION SIZE DISTRIBUTION

SIZE CLASS	INCH GROUP	NUMBER SAMPLED	SAMPLE PROPORTION	POPULATION ESTIMATE	ESTIMATED NUMBER	NUMBER SPEARED	PERCENT OF EST. NUMBER
	5	0	0.000		0	0	N/A
	6	0	0.000		0	0	N/A
	7	0	0.000		0	0	N/A
0-11.9	8	0	0.000	225	0	0	N/A
	9	0	0.000		0	0	N/A
	10	8	0.063		14	0	0.00%
	11	118	0.937		210	0	0.00%
	SUB-TOTAL:	126				0	0.00%
	12	726	0.350		1,943	11	0.57%
12-14.9	13	774	0.373	5,557	2,072	10	0.48%
	14	576	0.277		1,542	18	1.17%
	SUB-TOTAL:	2,076				39	0.70%
	15	423	0.647		1,329	13	0.98%
	16	160	0.245		503	4	0.80%
15-19.9	17	56	0.086	2,054	176	0	0.00%
	18	12	0.018		38	0	0.00%
	19	3	0.005		9	0	0.00%
	SUB-TOTAL:	654				17	0.83%
	20	1	0.083		1	0	0.00%
	21	4	0.333		5	0	0.00%
	22	0	0.000		0	0	N/A
	23	2	0.167		2	1	42.86%
	24	1	0.083		1	0	0.00%
	25	1	0.083		1	0	0.00%
20 +	26	2	0.167	14	2	0	0.00%
	27	0	0.000		0	0	N/A
	28	1	0.083		1	0	0.00%
	29	0	0.000		0	0	N/A
	30	0	0.000		0	0	N/A
	31	0	0.000		0	0	N/A
	SUB-TOTAL:	12				1	7.14%
	SPAWNING TOTAL:	2,868		7,850	7,850	57	0.73%
	UNKNOWNS < 15":	72				2	
	GRAND TOTAL:	2,940				59	

LAKE: SAND L | AREA: 928
COUNTY: SAWYER | RECRUITMENT CODE: C-ST
YEAR: 2012 | AGENCY: GLIFWC

DAILY SUMMARY AND COMMENTS

DATE: 3/24-4/2/2012 WATER TEMPERATURE:

COMMENTS: WDNR Fyke Netting.

	NUMBER NEWLY MARKED	SPAWNING CONDITION (APPROX. PERCENTAGE) HARD	RIPE	SPENT
MALES	56			
FEMALES	47			
UNKNOWN	70			
TOTAL	173			

DATE: 3/23-24/2012 WATER TEMPERATURE: 42-46

COMMENTS: Fish were scattered along shoreline.

	NUMBER NEWLY MARKED	SPAWNING CONDITION (APPROX. PERCENTAGE) HARD	RIPE	SPENT
MALES	412	0	100	0
FEMALES	115	100	0	0
UNKNOWN	24			
TOTAL	551			

DATE: 3/25,28/2012 WATER TEMPERATURE: 43/44

COMMENTS: Most walleye were found in 3-5' of water. Bluegill, sucker, and yellow perch were abundant.

	NUMBER NEWLY MARKED	SPAWNING CONDITION (APPROX. PERCENTAGE) HARD	RIPE	SPENT
MALES	576	0	100	0
FEMALES	17	100	0	0
UNKNOWN	1			
TOTAL	594			

DATE: 3/29-30/2012 WATER TEMPERATURE: 44

COMMENTS: Most walleye were in 2-4' of water.

	NUMBER NEWLY MARKED	SPAWNING CONDITION (APPROX. PERCENTAGE) HARD	RIPE	SPENT
MALES	487	0	100	0
FEMALES	24	100	0	0
UNKNOWN	19			
TOTAL	530			

DATE: 3/31-4/1/2012 WATER TEMPERATURE: 44/47

COMMENTS: Some walleye were tight to the shoreline, others were still in 2-4' of water.

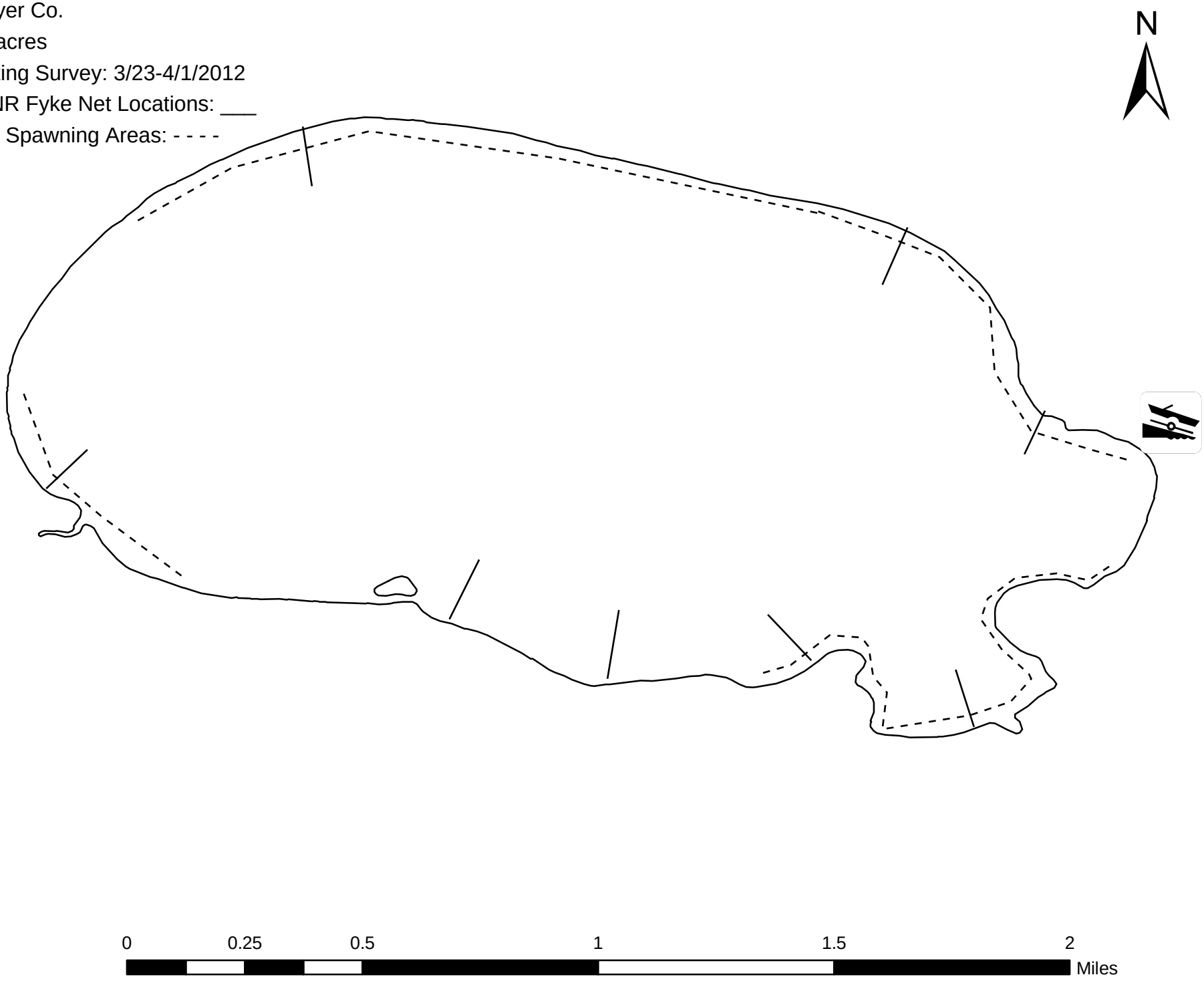
	NUMBER NEWLY MARKED	SPAWNING CONDITION (APPROX. PERCENTAGE) HARD	RIPE	SPENT
MALES	879	0	95	5
FEMALES	19	50	50	0
UNKNOWN	6			
TOTAL	904			

DATE: 4/2/2012 WATER TEMPERATURE: 45

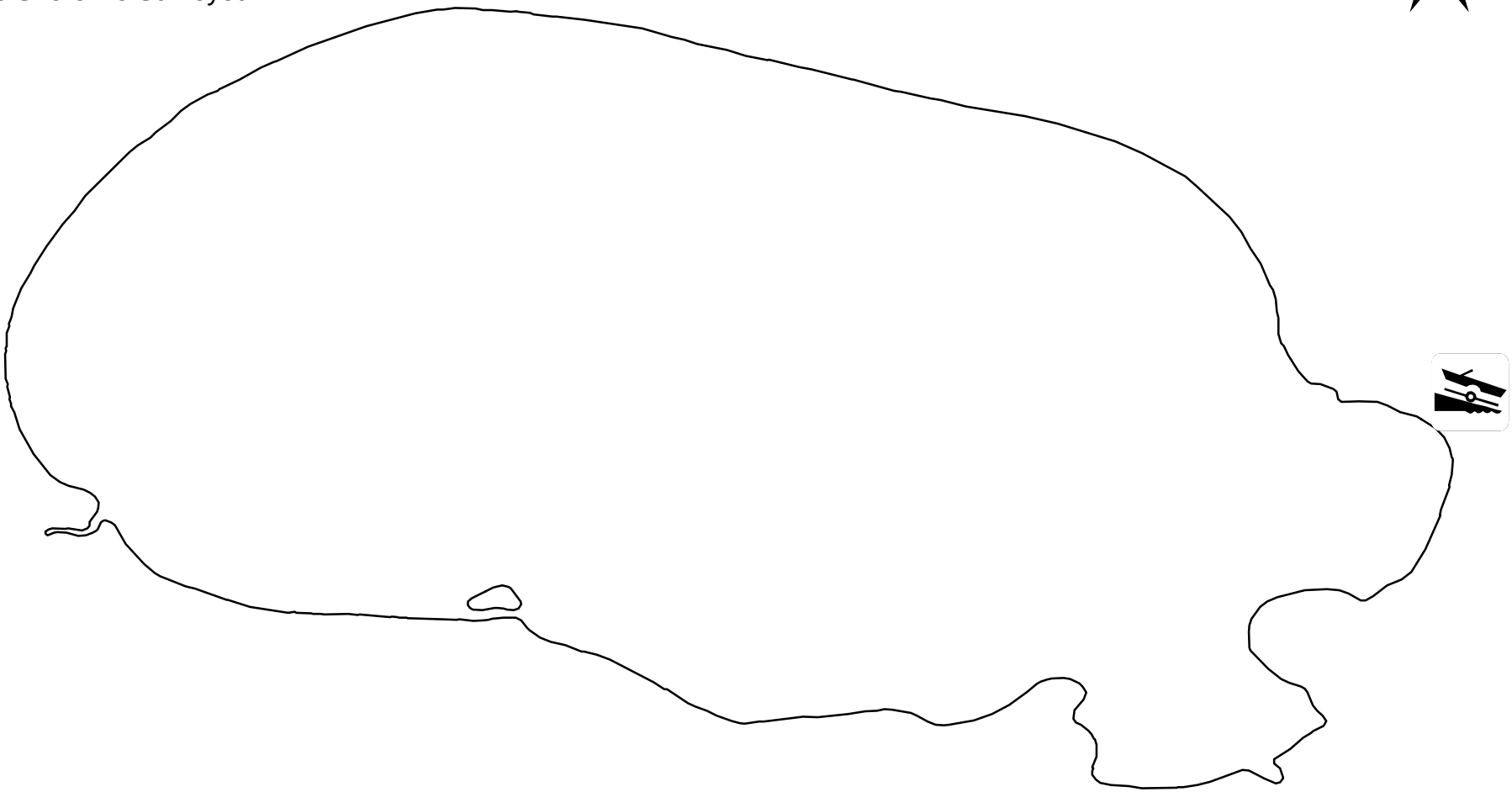
COMMENTS: Recapture run, shocked entire shoreline.

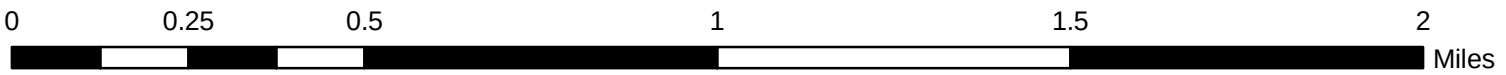
	NUMBER NEWLY MARKED	SPAWNING CONDITION (APPROX. PERCENTAGE) HARD	RIPE	SPENT
MALES	177	0	100	0
FEMALES	11	50	50	0
UNKNOWN	0			
TOTAL	188			

Sand Lake
Sawyer Co.
928 acres
Marking Survey: 3/23-4/1/2012
WDNR Fyke Net Locations: ___
Main Spawning Areas: - - - -



Sand Lake
Sawyer Co.
928 acres
Recapture Survey: 4/2/2012
Entire Shoreline Surveyed





Appendix B: Freshwater Sponge Information

Citizen Monitoring Guide to Wisconsin's Freshwater Sponges

Dreux J. Watermolen
Wisconsin Department of Natural Resources

Project Overview

Freshwater sponges are aquatic animals that grow in lakes, rivers, bogs, and streams attached to submerged rocks, sticks, logs, or aquatic vegetation. They feed by filtering small particles from the water, and so are thought to be sensitive indicators of pollution. Wisconsin's freshwater sponges were studied extensively in the 1930s and found to be growing in many lakes and major river systems. Since then, extensive studies have not been done, though some limited research seems to indicate that the range of some species is more restricted than in the 1930s. This Citizen-based Monitoring study will try to shed more light on how abundant and widely distributed Wisconsin's sponges are today. Through this project, we are engaging volunteer monitors and creating a database of probable sponge occurrences that can be further investigated.

Study Area

The Citizen Monitoring of Wisconsin's Freshwater Sponges project is a statewide inventory program. Citizens throughout the state are now able to collect and report data on sponge occurrence in their local lakes and waterways.

What Do Freshwater Sponges Look Like?

Freshwater sponges vary from marble-sized to elongated masses and can grow to be thin or thick encrusting layers. Their surfaces may be smooth, textured or wavy, or have finger-like projections (photos at right). Their structure is supported by spicules, tiny needle-like structures made of silicon that are distributed throughout the sponge body. You can use a magnifying glass to see at least a hint of the needle-like spicules.

Unfortunately, color and shape are not particularly helpful in identifying sponges to the species level. Instead, biologists rely on the spicules, which are quite diverse in their size, shape, and number of prongs (photo, lower right). Some have hooks or are dumbbell-shaped. They can be smooth or spined. Much of this variability is species-specific (i.e. each species has its own sizes and shapes).

Can We Find Freshwater Sponges in Our Lake or Nearby River?

Sponges grow in relatively shallow water and so can be found by wading and observing the surfaces where they might grow. You might find a rake useful for turning over debris. The sponges may be colored green by algae that live inside their cells or they may be beige to brown or pinkish in color. Sponges can be delicate to very firm feeling but are not slimy or filmy. Some sponges prefer the underside of logs and sticks; these are usually not green in color.

Wisconsin's sponges exhibit an annual life history in which they grow through the summer, die back in the winter, and begin a new growth cycle in spring. So, it's best to look for them in late summer and early fall. In late summer, sponges form gemmules, small spherical protective structures that contain cells from which new sponges will grow in spring. The gemmules will appear about the size of poppy seeds, but are tan in color (arrows in photo, below right). They can be clustered or scattered in the sponge.

How Common Are Freshwater Sponges?

We don't know. Since little modern survey research has been conducted, their conservation status remains unknown. Biologists have found sponges in fewer than half of Wisconsin's counties. So there are many gaps in our knowledge.

We created a reporting mechanism by which citizens can help us prioritize waterbodies for future survey efforts.

Please take one of our brochures and share your observations.

What Information Is Being Collected?

Citizen volunteers are asked to answer the following questions:

Where did you observe sponges?
- County: _____
- Waterbody: _____

Substrate where you observed sponges:
- _ sand
- _ gravel
- _ logs
- _ other: _____

When did you observe sponges?
- Date: _____

How many kinds of sponges did you observe?
- _ All sponges appeared to be the same kind
- _ Sponges appeared to be more than one kind

How can we contact you?
- Name: _____
- Address: _____
- _____
- Telephone: _____
- E-mail: _____

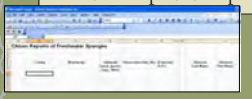
Where Do Volunteers Send Their Reports?

Volunteers can mail their completed questionnaires to:

Dreux Watermolen, SS/7
Wisconsin Dept. of Natural Resources
P.O. Box 7921
Madison, WI 53707-7921

Or they can send all of the requested information by e-mail to dreux.watermolen@wisconsin.gov.

Submitted information will be compiled in a database of probable sponge occurrences.



Acknowledgments

Photographs: Robert Korth and Milwaukee Public Museum

Thanks to Joan Jass, Janis Annesley, and the Milwaukee Public Museum for assistance in developing this sponge monitoring program and the introductory brochure. This project is supported by the Wisconsin Department of Natural Resources' Citizen-Based Monitoring Partnership Program. For more information on the Citizen-Based Monitoring Partnership Program, see http://cbm.wiatri.net/.

Appendix C: Sand Lake Aquatic Plant Survey Report

Sand Lake Aquatic Plant Survey

Introduction

This report is a summary and analysis of the data which was collected in a baseline macrophyte survey of Sand Lake, Sawyer County WI. The macrophyte survey was completed the last week of August 2012 and followed WI DNR protocol for a point-intercept survey. The entire littoral zone was also visually surveyed in mid June for the presence of invasive species, of which none were found.

Field Methods

A point intercept method for the macrophyte sampling was used. The Wisconsin Department of Natural Resources (WDNR) generated the sampling point grid. This grid consisted of 830 points (Figure 1). Only points shallower than 20 feet were initially sampled until the maximum depth of plants could be established. It was determined that the maximum depth of plants was 11 feet. A total of 279 points were sampled. From those 279 points, 250 points were at depths of 11 feet or less and 208 of them contained vegetation.

If no plants were sampled at a specific depth, one sample point beyond that depth was sampled for plants. In addition, any plant within six feet of the boat was recorded. The visually surveyed plant data is not used in the statistical analysis nor is the density recorded. Only results from the predetermined sample points were used in the statistical analysis. A handheld Global Positioning System (GPS) located the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy were followed with an 80-foot resolution and the location arrow touching the point.

At each sample location, a double-sided fourteen-tine rake was used to rake a 1 meter tow from off the bow of the boat. All plants contained on the rake and those that fell off of the rake were identified and rated as to rake fullness. The rake fullness value was used based on the criteria contained in the diagram below. Those plants that were within six feet were recorded as "viewed," but no rake fullness rating was given.

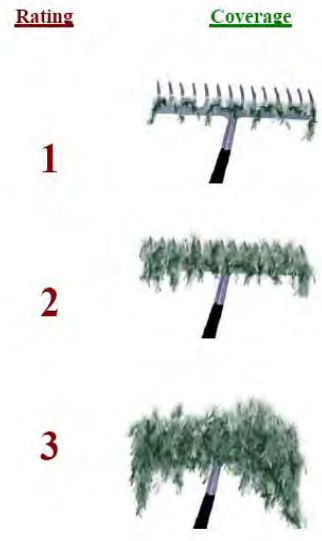
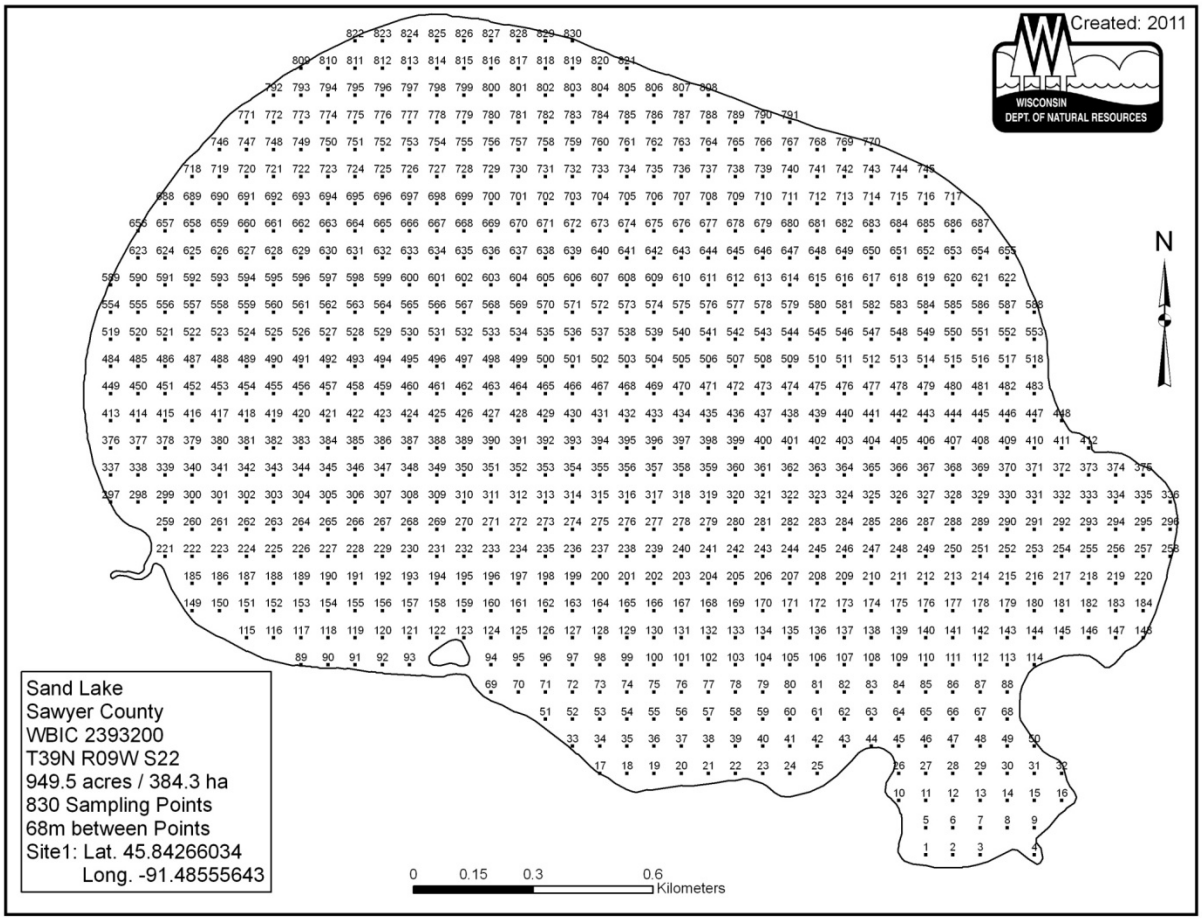


Figure 1: Sand Lake Sampling Point Grid



The depth and predominant bottom type was also recorded for each sample point. All plants needing verification were bagged and cooled for later examination.

Data Analysis Methods

The data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Frequency of occurrence in sample points with vegetation (littoral zone)
- Relative frequency
- Total sample points
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

Frequency of occurrence for each species
Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the number of total sites. There are two frequency values calculated. The first is the percentage of all sample points that a plant was sampled at depths less than the maximum depth plants were found (littoral zone), regardless if vegetation was present. The second is the percentage of sample points that the plant was sampled out of only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone, while the second value considers only points that contain plants. In either case, the greater this value, the more frequently the plant occurs in the lake. If one wants to compare plants within the littoral zone, we look at the frequency of all points below maximum depth with plants. This frequency value allows the analysis of how common plants are in areas where they could grow. If one wants to focus only on where plants are actually present, then one would look at frequency at points in which plants were found. Frequency of occurrence is usually reported using sample points where vegetation was present.

Relative frequency
This value shows, as a percentage, the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants will add to 100%. This means that if plant A had a relative frequency of 30%, it occurred 30% of the time compared to all plants sampled or makes up 30% of all plants sampled. This value allows us to see which plants are the dominant species in the lake. The higher the relative frequency, the more common the plant is compared to the other plants.

Total Sample Points
This is the total number of points created for sampling on the lake. This may not be the same as the actual points sampled. When doing a survey, samples aren't taken at depths outside of the littoral zone (the area where plants can grow). Once the maximum depth of plants is established, many of the points deeper than this are eliminated to save time and effort.

Sample points with vegetation
This is the number of sites where plants were actually sampled. It gives a good idea of the plant coverage of the lake. If 20% of all grid sample points had vegetation, it implies about 20% coverage of plants in the whole lake. We also look at the number of sample sites with vegetation in the littoral zone. If 20% of the littoral zone had sample points with vegetation, then the plant coverage in the littoral zone would be estimated at 20%.

Simpson's diversity index
Simpson's diversity index is calculated to measure how diverse the plant community is. This value can run from 0 to 1.0. The greater the value, the more diverse the plant community is in a particular lake. In theory, the value is the chance that two species sampled are different. An index of "1" means that the two will always be different (very diverse) and a "0" would indicate that they will never be different (only one species found). The more diverse the plant community, the better the lake ecosystem.

Maximum depth of plants
This depth indicates the deepest that plants were sampled. Generally lakes with higher water clarity have a greater depth of plants while lower water clarity limits light penetration and reduces the depth at which plants are found.

Species richness
The number of different individual species found in the lake. Results include a number for the species richness of plants sampled, and another number that takes into account plants viewed but not actually sampled during the survey.

Floristic Quality Index
The Floristic Quality Index (FQI) is an index developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index is a measure of the plant community in response to development (and human influence) on the lake. It takes into account the species of aquatic plants found and their tolerance for changing water quality and habitat quality. The index uses a conservatism value assigned to various plants ranging from 1 to 10. Not all plants have a conservatism value. A high conservatism value indicates that a plant is intolerant to disturbance while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes, largely due to human influence.

The FQI is calculated using the number of species and the average conservatism value of all species used in the index.

The formula is:

$$FQI = \text{Mean } C \cdot \sqrt{N}$$

Where C is the conservatism value and N is the number of species.

A higher FQI, indicates a healthier aquatic plant community. This value can then be compared to the mean for other lakes in the assigned eco-region. There are four eco-regions used throughout Wisconsin. These are Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain. Sand Lake is located in the Northern Lakes and Forest eco-region. Below is a summary of the FQI median values for the Northern Lakes and Forest eco-region:

Mean species richness = 13
Mean conservatism = 6.7
Mean Floristic Quality = 24.3[1]

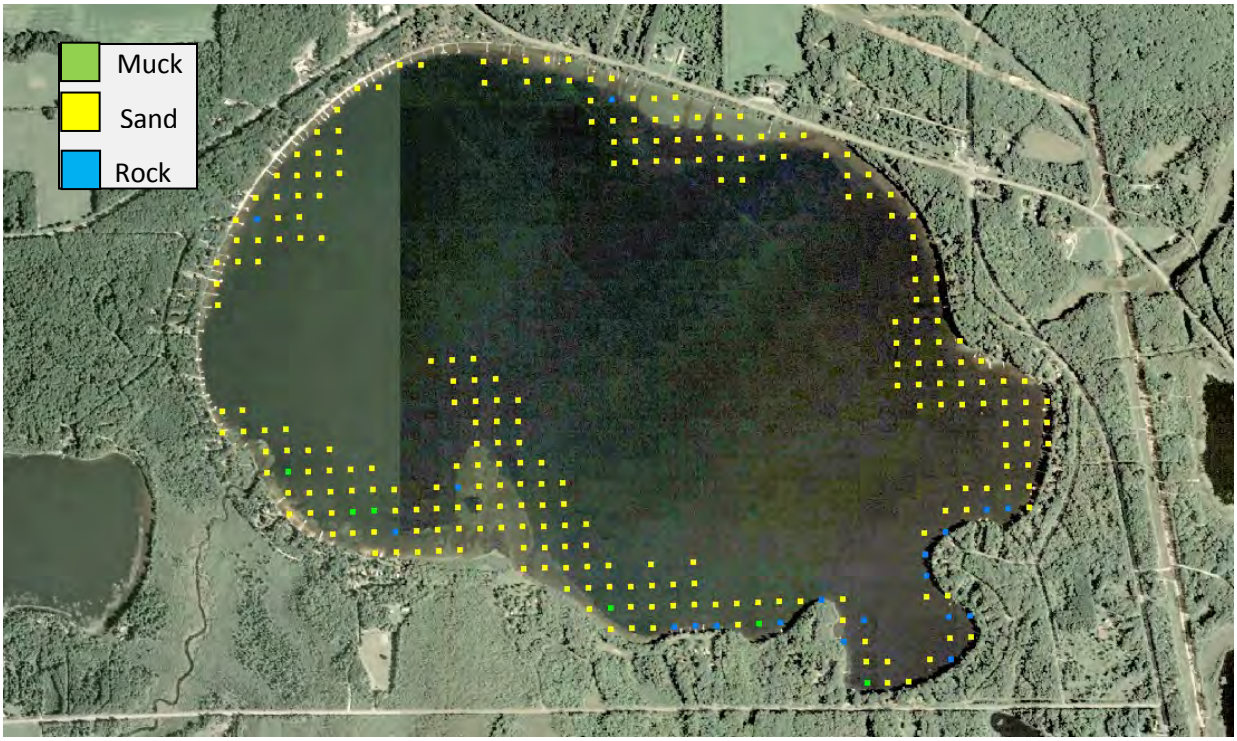
[1] Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management 15 (2): 133-144. 1999.

Results

The Wisconsin Department of Natural Resources generated the sampling point grid for Sand Lake which consisted of 830 points. Only points shallower than 20 feet were initially sampled until the maximum depth of plants could be established. This was determined to be 11 feet and is considered the littoral zone. A total of 250 points were at depths of 11 feet or less and out of those points, 208 of them contained vegetation. See Table 1 for a summary of the survey statistics.

Figure 2 shows the points that were sampled at depths of 11 feet or less and can be considered a map of the littoral zone. It also indicates the type of substrate that was present at each of the littoral zone sampling points. Sand was the most dominant substrate type (91%) followed by rock (7%) and then muck (2%).

Figure 2: Sand Lake Littoral Zone and Substrate Type



Species Richness

Twenty-seven species of aquatic macrophytes were directly sampled and observed in Sand Lake during the August whole lake survey. Table 2 lists all of the species that were sampled or observed along with their frequency and average rake density.

Table 1: Sand Lake Aquatic Plant Survey Statistics

SUMMARY STATS:	
Total number of points sampled	279
Total number of sites with vegetation	208
Total number of sites shallower than maximum depth of plants	250
Frequency of occurrence at sites shallower than maximum depth of plants	83.20
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	11.00
Number of sites sampled using rake on Rope (R)	111
Number of sites sampled using rake on Pole (P)	167
Average number of all species per site (shallower than max depth)	2.54
Average number of all species per site (veg. sites only)	3.06
Average number of native species per site (shallower than max depth)	2.32
Average number of native species per site (veg. sites only)	3.06
Species Richness	27
Species Richness (including visuals)	27

Table 2: Sand Lake Aquatic Macrophytes

Species Name	Common Name	Freq w/in vegetated areas	Freq at sites shallower than max depth of plants	Relative Freq.	Rake Density
Vallisneria americana	Wild celery	65.87	54.8	21.5	1
Potamogeton pusillus	Small pondweed	27.4	22.8	9	1
filamentous algae	filamentous algae	26.44	22	8.6	1
Najas flexilis	Bushy pondweed	26.44	22	8.6	1
Potamogeton richardsonii	Clasping-leaf pondweed	22.12	18.4	7.2	1
Potamogeton amplifolius	Large-leaf pondweed	21.63	18	7.1	1
isoetes sp.	quillwort	13.94	11.6	4.6	1
Schoenoplectus acutus	Hardstem bulrush	13.46	11.2	4.4	1
Elodea canadensis	Common waterweed	11.06	9.2	3.6	1
Myriophyllum tenellum	Dwarf water milfoil	11.06	9.2	3.6	1

Species Name	Common Name	Freq w/in vegetated areas	Freq at sites shallower than max depth of plants	Relative Freq.	Rake Density
Potamogeton illinoensis	Illinois pondweed	10.58	8.8	3.5	1
Potamogeton robbinsii	Fern Leaf pondweed	8.17	6.8	2.7	1
Chara	Muskgrasses	7.21	6	2.4	1
Potamogeton zosteriformis	Flat-stem pondweed	6.73	5.6	2.2	1
Ceratophyllum demersum	Coontail	6.25	5.2	2	1
Schoenoplectus pungens	Three-square rush	6.25	5.2	2	1
Nitella sp.	Nitella	5.77	4.8	1.9	2
Nuphar variegata	Spatterdock	3.37	2.8	1.1	1
Megalodonta beckii	Water marigold	2.4	2	0.8	1
Myriophyllum sibiricum	Northern water milfoil	1.92	1.6	0.6	1
Ranunculus aquatilis	Stiff water crowfoot	1.44	1.2	0.5	1
Brasenia schreberi	Watershield	1.44	1.2	0.5	1
Lemna minor	Small duckweed	1.44	1.2	0.5	1
Equisetum fluviatile	water horsetail	0.96	0.8	0.3	1
Eriocaulon aquaticum	Pipewort	0.96	0.8	0.3	1
Nymphaea odorata	White water lily	0.96	0.8	0.3	1
Potamogeton strictifolius	Stiff pondweed	0.48	0.4	0.2	1

Frequency of occurrence within vegetated areas (%): *Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.*

Frequency of occurrence at sites shallower than maximum depth of plants: *Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants (whole lake value-how often it occurs within the entire littoral zone)*

Plant Diversity

Sand Lake has a very diverse plant community consisting of 27 native species. The Simpson's diversity index is also very high at 0.91 indicating a healthy ecosystem and a high degree of diversity. No single plant dominates within the lake. The plant species abundance is balanced between many different types.

Floristic Quality Index

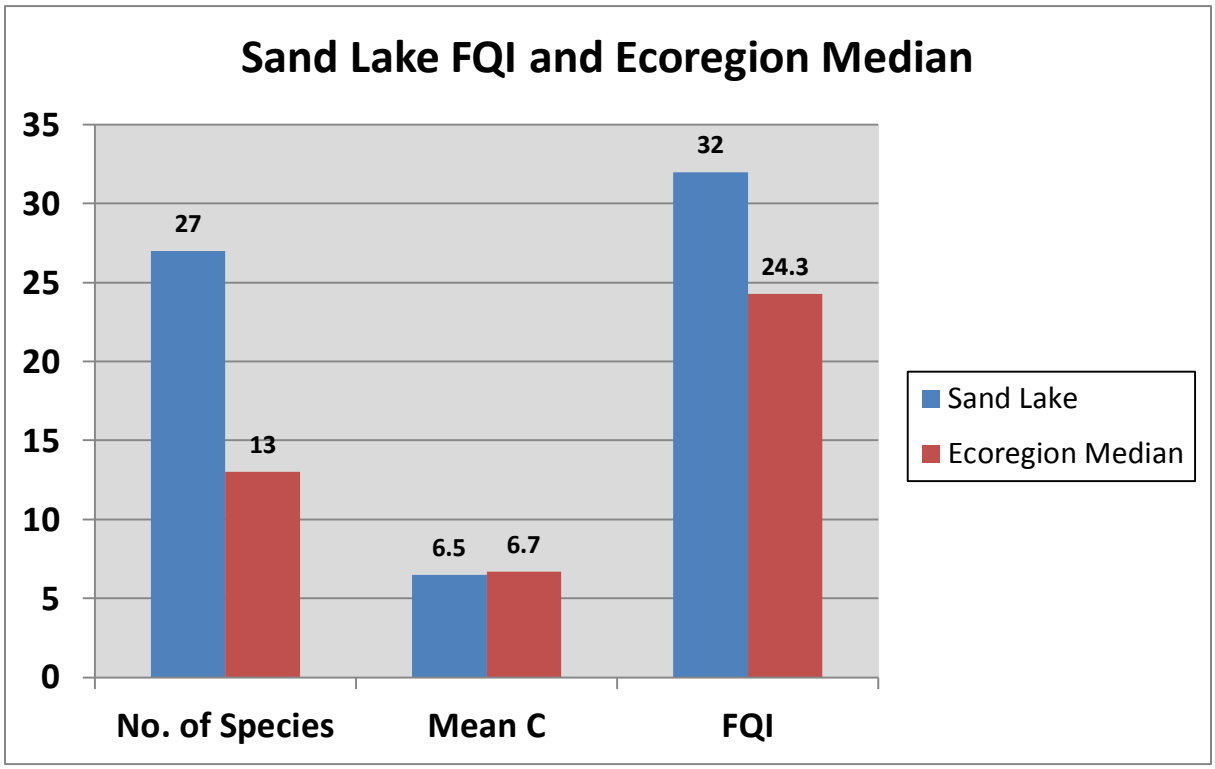
Sand Lake has a very high FQI (32.0). There were 24 species used to calculate the FQI. The species and their conservatism values are included in Table 3. The mean conservatism value was 6.54. The number of species and FQI are greater than the median values for lakes in the same eco-region (Northern Lakes and Forests). The mean conservatism value is slightly lower however. Figure 3 compares these values. The high FQI is indicative of a plant community that is intolerant to development and other human disturbances in the watershed. It indicates that the plant community is healthy and has changed little in response to human impact on water quality and habit (sediment) changes.

Table 3: Plant Conservatism Values

Species Name	Common Name	Conservatism Value
Elodea canadensis	Common waterweed	3
Vallisneria americana	Wild celery	6
Ceratophyllum demersum	Coontail	3
Potamogeton zosteriformis	Flat-stem pondweed	6
Chara	Muskgrasses	7
Potamogeton strictifolius	Stiff pondweed	8
Potamogeton robbinsii	Fern Leaf pondweed	8
filamentous algae	filamentous algae	
Najas flexilis	Bushy pondweed	6
Potamogeton pusillus	Small pondweed	7
Nitella sp.	Nitella	
Potamogeton richardsonii	Clasping-leaf pondweed	5
Myriophyllum tenellum	Dwarf water milfoil	10
Megalodonta beckii	Water marigold	8
Myriophyllum sibiricum	Northern water milfoil	7
Ranunculus aquatilis	Stiff water crowfoot	7
isoetes sp.	quillwort	8
Equisetum fluviatile	water horsetail	7
Eriocaulon aquaticum	Pipewort	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Schoenoplectus acutus	Hardstem bulrush	5
Brasenia schreberi	Watershield	7
Nymphaea odorata	White water lily	6

Species Name	Common Name	Conservatism Value
Schoenoplectus pungens	Three-square rush	
Nuphar variegata	Spatterdock	6
Lemna minor	Small duckweed	5

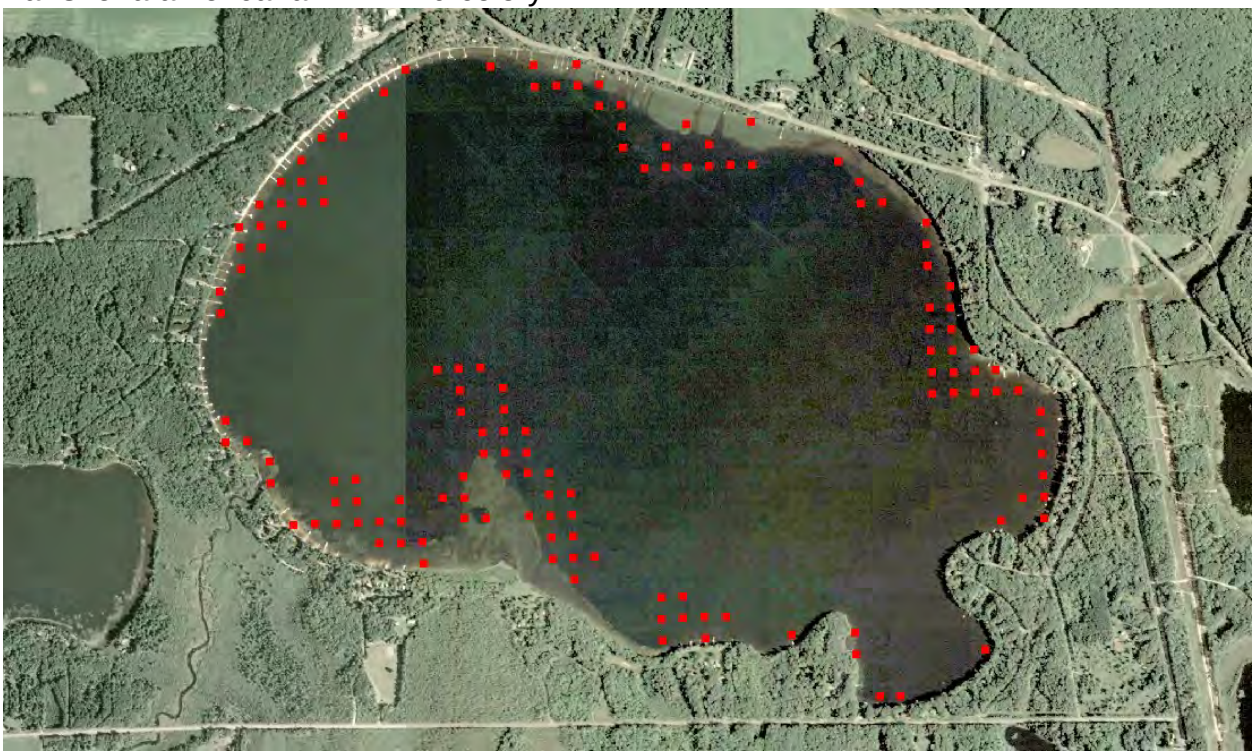
Figure 3: FQI Comparison to Ecoregion Median



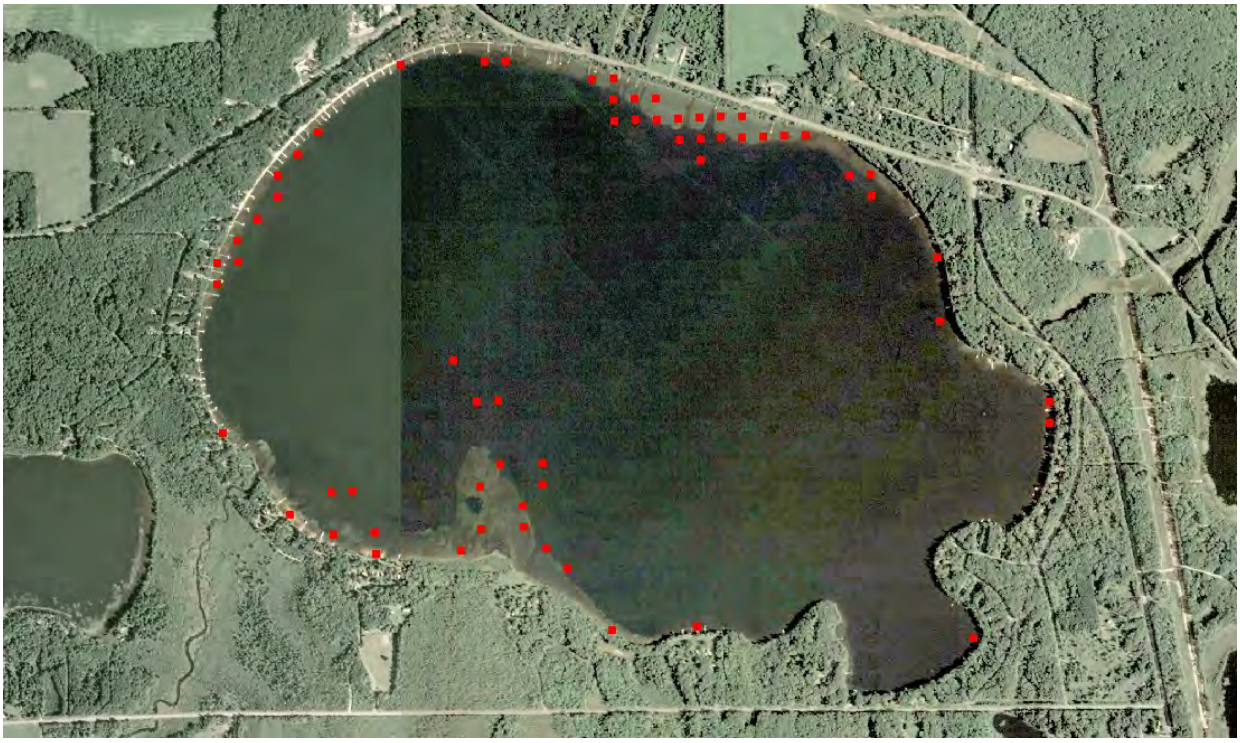
Species Distribution Maps

The following maps indicate the locations that the specified plant was surveyed or visually seen during the August whole lake point-intercept survey.

Vallisneria americana Wild celery



Potamogeton pusillus Small pondweed



filamentous algae

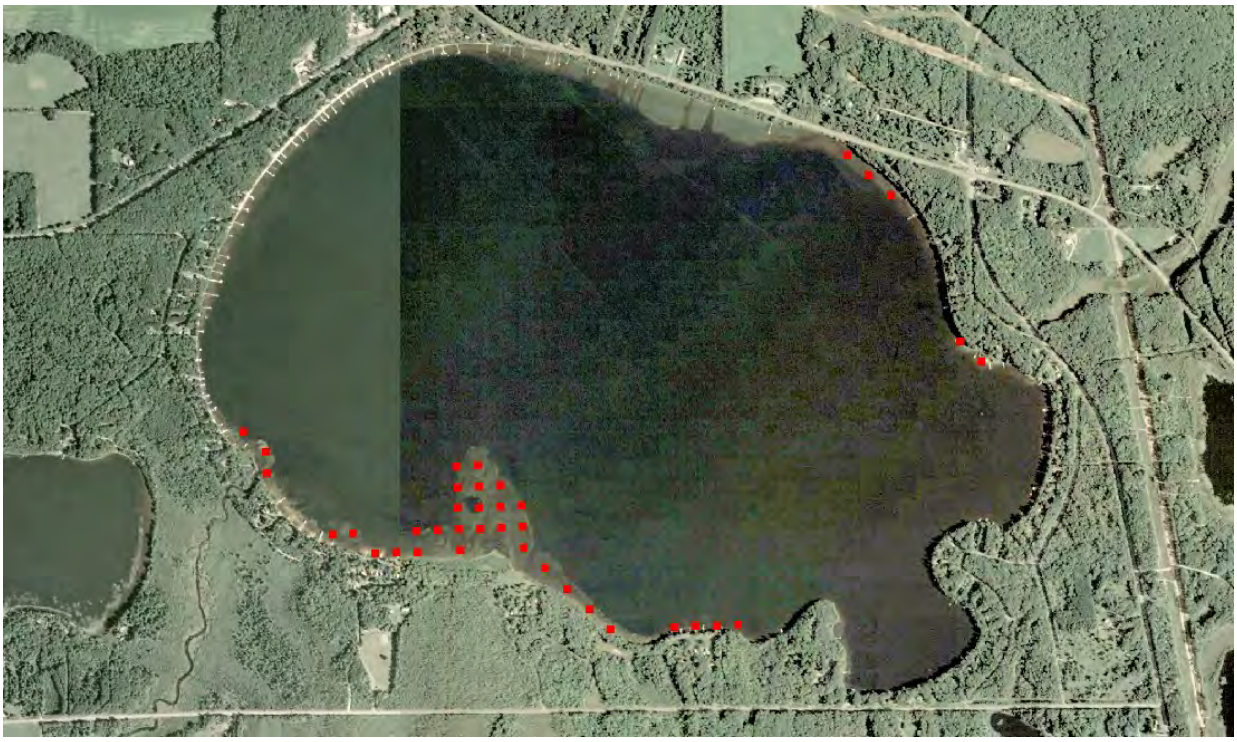
Najas flexilis Bushy pondweed

Potamogeton richardsonii Clasping-leaf pondweed

Potamogeton amplifolius Large-leaf pondweed

isoetes sp. quillwort

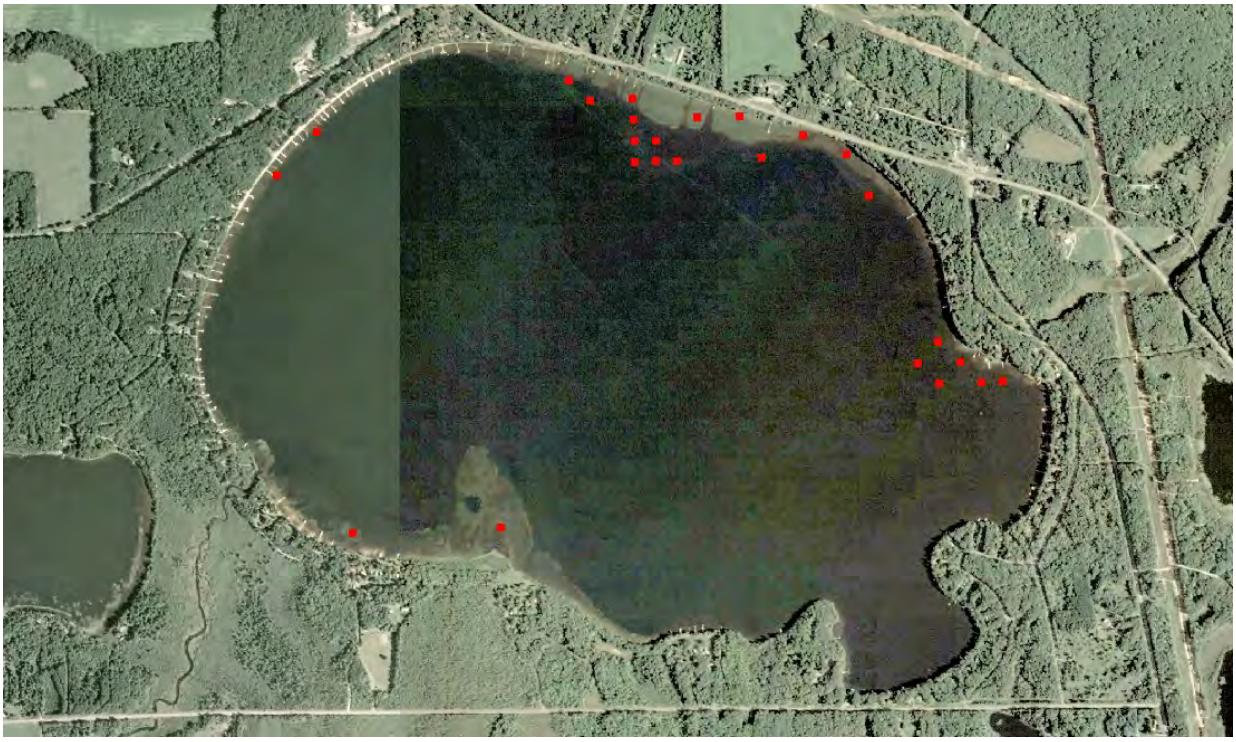
Schoenoplectus acutus Hardstem bulrush



Elodea canadensis Common waterweed

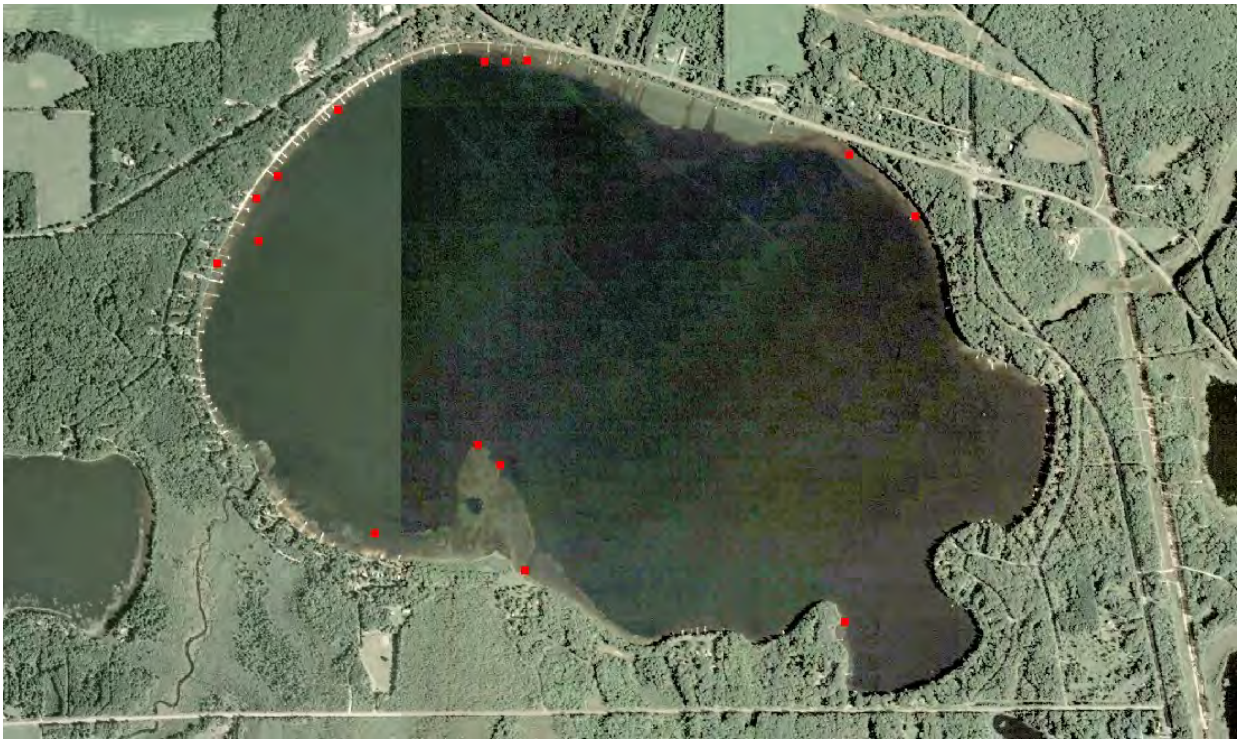
Myriophyllum tenellum Dwarf water milfoil

Potamogeton illinoensis Illinois pondweed



Potamogeton robbinsii Fern Leaf pondweed

Chara Muskgrasses



Potamogeton zosteriformis Flat-stem pondweed

Ceratophyllum demersum Coontail

Schoenoplectus pungens Three-square rush

Nitella sp. Nitella

Nuphar variegata Spatterdock

Megalodonta beckii Water marigold

Myriophyllum sibiricum Northern water milfoil

Ranunculus aquatilis Stiff water crowfoot

Brasenia schreberi Watershield

Lemna minor Small duckweed

Equisetum fluviatile water horsetail

Eriocaulon aquaticum Pipewort

Nymphaea odorata White water lily

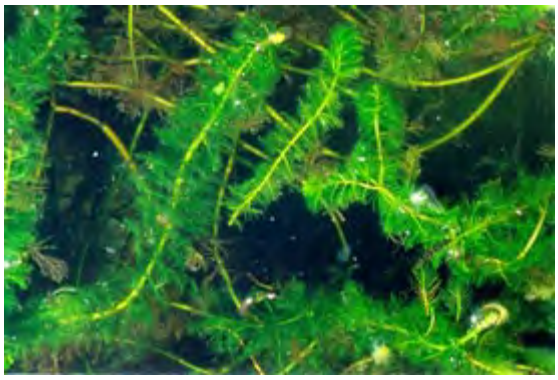
Potamogeton strictifolius Stiff pondweed

Appendix D. Aquatic Invasive Species Information[1]

Eurasian Water Milfoil

DESCRIPTION: Eurasian water milfoil is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, Eurasian water milfoil is nearly impossible to distinguish from Northern water milfoil. Eurasian water milfoil has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

DISTRIBUTION AND HABITAT: Eurasian milfoil first arrived in Wisconsin in the 1960's. During the 1980's, it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. As of 1993, Eurasian milfoil was common in 39 Wisconsin counties (54%) and at least 75 of its lakes, including shallow bays in Lakes Michigan and Superior and Mississippi River pools.



Eurasian Water Milfoil
(c) Barry A. Rice/The Nature Conservancy

Eurasian water milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

LIFE HISTORY AND EFFECTS OF INVASION: Unlike many other plants, Eurasian water milfoil does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These

[1] WI DNR Aquatic Invasive Species Fact Sheets

shoots may then be carried downstream by water currents or inadvertently picked up by boaters. Milfoil is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets, and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian water milfoil is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of Eurasian milfoil provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes.

CONTROLLING EURASIAN WATER MILFOIL: Preventing a milfoil invasion involves various efforts. Public awareness of the necessity to remove weed fragments at boat landings, a commitment to protect native plant beds from speed boaters and indiscriminate plant control that disturbs these beds, and a watershed management program to keep nutrients from reaching lakes and stimulating milfoil colonies--all are necessary to prevent the spread of milfoil.

Monitoring and prevention are the most important steps for keeping Eurasian water milfoil under control. A sound precautionary measure is to check all equipment used in infested waters and remove all aquatic vegetation upon leaving the lake or river. All equipment, including boats, motors, trailers, and fishing/diving equipment, should be free of aquatic plants.

Lake managers and lakeshore owners should check for new colonies and control them before they spread. The plants can be hand pulled or raked. It is imperative that all fragments be removed from the water and the shore. Plant fragments can be used in upland areas as a garden mulch.

Mechanical Control: Mechanical cutters and harvesters are the most common method for controlling Eurasian water milfoil in Wisconsin. While harvesting may clear out beaches and boat landing by breaking up the milfoil canopy, the method is not selective, removing beneficial

aquatic vegetation as well. These machines also create shoot fragments, which contributes to milfoil dispersal. Harvesting should be used only after colonies have become widespread, and harvesters should be used offshore where they have room to turn around. Hand cutters work best inshore, where they complement hand pulling and bottom screening. Bottom screening can be used for severe infestations, but will kill native vegetation as well. A diver-operated suction dredge can be used to vacuum up weeds, but the technique can destroy nearby native plants and temporarily raise water turbidity.

Hand pulling is the preferred control method for colonies of under 0.75 acres or fewer than 100 plants. The process is both thorough and selective (not to mention time-consuming); special care must be taken to collect all roots and plant fragments during removal. Sites remote from boat traffic can be covered with bottom screens that are anchored firmly against the lake bed to kill grown shoots and prevent new sproutings, but screens must be removed each fall to clean off sediment that encourages rooting. Buoys can mark identified colonies and warn boaters to stay away.

Whenever possible, milfoil control sites should become customized management zones. For example, colony removal by harvesting can be followed by planting native plants to stabilize sediments against wave action, build nurseries for fry, attract waterfowl, and compete against new milfoil invasions.

DNR permits are required for chemical treatments, bottom screening, and buoy/barrier placement.

Chemical Control: Herbicide treatment is not recommended because it is typically disruptive to aquatic ecosystems and not selective in the vegetation it affects, thus threatening native plants.

Biological Control: *Eurhychiopsis lecontei*, an herbivorous weevil native to North America, has been found to feed on Eurasian water milfoil. Adult weevils feed on the stems and leaves, and females lay their eggs on the apical meristem (top-growing tip); larvae bore into stems and cause extensive damage to plant tissue before pupating and emerging from the stem. Three generations of weevils hatch each summer, with females laying up to two eggs per day. It is believed that these insects are causing substantial decline in some milfoil populations. Because this weevil prefers Eurasian water milfoil, other native aquatic plant species, including northern watermilfoil, are not at risk from the weevil's introduction. Twelve Wisconsin lakes are currently part of a two-year DNR project studying the weevil's effectiveness in curbing Eurasian water milfoil populations. The fungi *Mycoleptidiscus terrestris* is also under extensive research.

Curly Leaf Pondweed

Photo by Elizabeth J Czarapata

DESCRIPTION: Curly-leaf pondweed is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early July

DISTRIBUTION AND HABITAT: Curly-leaf pondweed is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine

LIFE HISTORY AND EFFECTS OF INVASION: Curly-leaf pondweed spreads through burr-like winter buds (turions), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring.

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and outcompete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation.

CONTROL METHODS: Turions and plant fragments can be carried on boats, trailers, motors and fishing gear from one water body to another, thus proper prevention techniques are essential to curb the spread of this aquatic invasive. An effective prevention and remediation program also addresses the overall health of a water body: Maintaining a healthy ecosystem with diverse native aquatic plants and animals as well as minimizing nutrient and pollutant inputs will deter invasions. Once introduced, curly-leaf pondweed spreads rapidly. Long-term management requires the reduction or elimination of turions to interrupt the lifecycle.

DNR permits are required for chemical treatments, mechanical treatments, some manual treatments, biological control, bottom screening, and buoy/barrier placement.

Manual/Mechanical Control: To have the maximum benefit, manual/mechanical control efforts should be undertaken in the spring or early summer. Mechanical control includes raking, hand-cutting or harvesting vegetation. Raking and hand cutting remove plants at the sediment surface, and there is some evidence that early season cutting of pondweed can prevent turion production. Harvesting generally removes the top 5 feet of the plant. Curly-leaf pondweed can spread from plant fragments, so it is important to clean all vegetation off boats and equipment before leaving water access.

Chemical Control: There are a small number of aquatic herbicides that can be used to control curly-leaf pondweed. In Minnesota, good to excellent control was obtained using formulations of diquat (Reward) and endothall (Aquathall K). These chemicals can be used in small areas and will usually knock down curly-leaf pondweed within 2 weeks. The best time for treatment is in spring or early summer when natives are still dormant and temperatures are low enough for endothall be effective. In early experiments with fluridone (Sonar), production of turions was completely inhibited following early season treatments. Fluridone usually has to be applied to an entire lake and requires 30 days to knock down curly-leaf pondweed.

Habitat manipulation: Habitat manipulation such as drawdowns and dredging can also be used to manage curly-leaf pondweed. Fall drawdown can kill the plants by exposing them to freezing temperatures and desiccation. Dredging can be used as a control by increasing the water depth. In deep water, the plants do not receive enough light to survive. This method can be detrimental to desired plants, as all macrophytes would be prevented from growing for many years. This high level of disturbance may also create favorable conditions for the invasion of other invasive species.

Purple Loosestrife

Description

Purple loosestrife is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta, possess 5-6 petals aggregated into numerous long spikes, and bloom from July to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat.

Photo by Kenneth J. Sytsma Courtesy of Wisconsin Vascular Plants Website

By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Distribution and Habitat

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, about 24 states have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

Life History and Effects of Invasion

Purple loosestrife can germinate successfully on substrates with a wide range of pH. Optimum substrates for growth are moist soils of neutral to slightly acidic pH, but it can exist in a wide range of soil types. Most seedling establishment occurs in late spring and early summer when temperatures are high.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

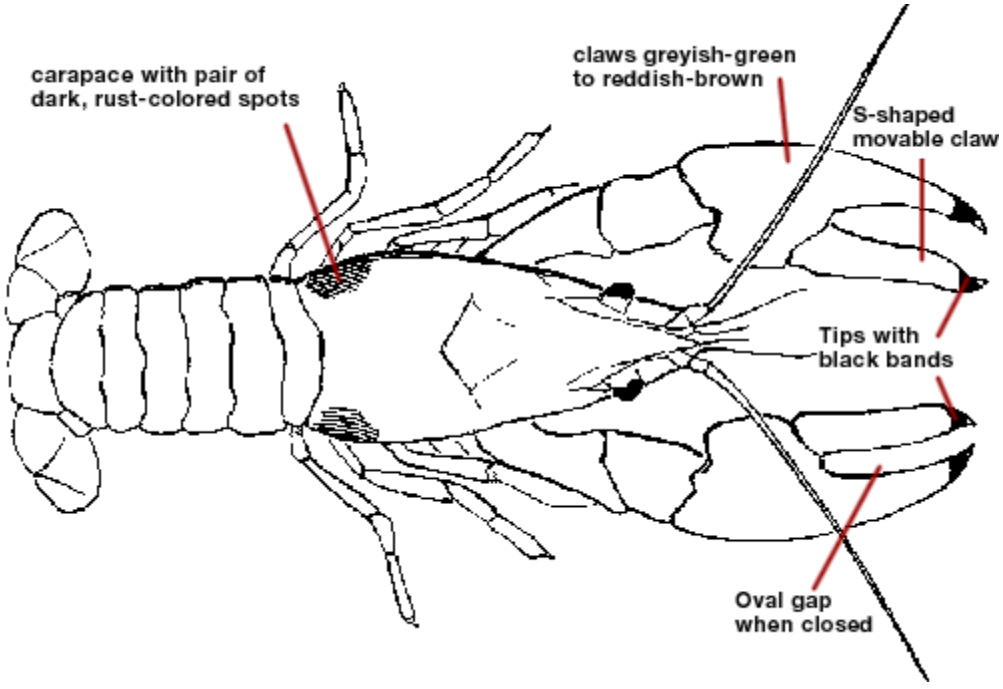
Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

Rusty Crayfish (*Orconectes rusticus*)

Rusty crayfish are invasive crustaceans spreading to lakes, rivers, and streams in several areas of North America. They are more aggressive than other native crayfish, better able to avoid fish predation, and can harm native fish populations by eating their eggs and young. They can displace native crayfish, hybridize with them, and graze on and eliminate aquatic plants.

Native to the Ohio River drainage, rusty crayfish have spread to several U.S. states and Ontario. They have likely spread through bait bucket release by anglers, aquarium release by hobbyists, activities of commercial harvesters, and live study specimen release by teachers and students who buy them from biological supply houses. Females can carry fertilized eggs or a male's sperm so even the release of a single female could establish a new population. Eradicating established infestations is impossible. Your help detecting and reporting new infestations is vital to preventing their spread.

Identify Rusty Crayfish


carapace with pair of dark, rust-colored spots
claws greyish-green to reddish-brown
S-shaped movable claw
Tips with black bands
Oval gap when closed

General Characteristics

- Adults generally are 3-5 inches (7-13 cm) long
- Claws larger and smoother than many other crayfish; usually without wart-like white bumps
- Claws with oval gap when closed; no distinct thin slit or notch present

What You Can Do

- Learn to identify rusty crayfish
- Inspect and remove aquatic plants and animals from boat, motor, and trailer
- Drain lake or river water from live well and bilge before leaving access
- Dispose of unwanted live bait and study specimens in the trash
- Never dump live fish or crayfish from one body of water into another
- Report new sightings - record exact location; store specimens in rubbing alcohol; if in Minnesota, call the MN Department of Natural Resources Invasive Species Program in St. Paul, 1-888-MINNDNR, or Doug Jensen of Minnesota Sea Grant.

Know the rules!

Specimens are needed to confirm sightings, but some jurisdictions prohibit or discourage possession and transport of rusty crayfish and other invasive aquatic plants and animals. Contact your local natural resource management agency for instructions. Unauthorized introduction of plants or fish into the wild is illegal. Protect your property and our waters.

Spiny Waterflea and Fishhook Waterflea(*Bythotrephes cederstroemi* and *Cercopagis pengoi*)

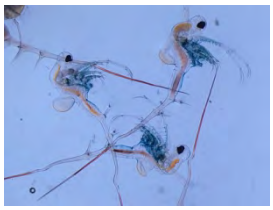


Photo by Pieter Johnson, UW Center for Limnology

Both waterfleas entered the Great Lakes in ship ballast water from Europe – the spiny waterflea arrived in the 1980's, followed in the 1990's by the fishhook water flea. Only about ¼ to ½ inches in length, individual waterfleas may go unnoticed. However, both species tend to gather in masses on fishing lines and downrigger cables, so anglers may be the first to discover a new infestation.

Spiny and fishhook waterfleas are predators - they eat smaller zooplankton (planktonic animals), including Daphnia. This puts them in direct competition with juvenile fish for food. Young fish have trouble eating these waterfleas due to their long, spiny tails. The spiny and fishhook water fleas produce rapidly through parthenogenesis, commonly known as asexual reproduction, which means that no males are required and populations can explode in number.

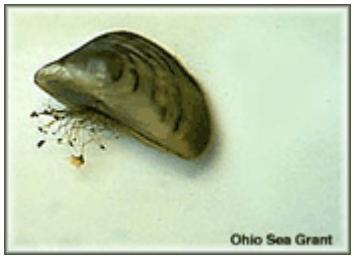
Fishing, boating, and other water recreational equipment can transport spiny waterfleas and their eggs to new water bodies. Their resting eggs can survive long after the adults are dead, even under extreme environmental conditions. So care must be taken not to transport water between water bodies and to remove all waterfleas and eggs from equipment.

Spiny water fleas were found in the Gile Flowage (Iron County) in 2003 and Stormy Lake (Vilas County) in 2007. These are the only inland Wisconsin lakes known to contain invasive water fleas. Unfortunately, at this time no effective strategy is available to control the spiny water fleas once they are introduced to lakes.

Anyone who thinks they may have spotted spiny water fleas in other inland Wisconsin lakes is asked to contact their local DNR office or call (608) 266-9270

Zebra Mussels (*Dreissena polymorpha*)

DESCRIPTION: The zebra mussel (*Dreissena polymorpha*) is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.



DISTRIBUTION AND HABITAT: Zebra mussels were first found in Wisconsin waters of Lake Michigan in 1990. They are now found in a number of inland Wisconsin waters (see current infestation list and maps). By 1991, the mussels had made their way into Pool 8 of the Mississippi River, most likely originating in the Illinois River (currents may have carried them to the confluence with the Mississippi, from which barges could carry them upriver). Populations of zebra mussels are steadily increasing to over several thousand per square meter in some portions of the Mississippi river. As of 2003, their distribution included the entire Wisconsin portion of the Mississippi and extended up to Stillwater in the St Croix River.

Zebra mussels are the only freshwater mollusks that can firmly attach themselves to solid objects. They are generally found in shallow (6-30 feet deep), algae-rich water.

LIFE HISTORY AND EFFECTS OF INVASION: Zebra mussels usually reach reproductive maturity by the end of their first year. Reproduction occurs through spawning when sperm and eggs are released into the water. Spawning peaks at water temperatures of about 68 degrees F. A fertilized egg results in a free-swimming, planktonic larva called a 'veliger.' This veliger remains suspended in the water column for one to five weeks, and then begins to sink, eventually attaching to a stable surface (e.g., rocks, dock pilings, aquatic weeds, water intakes, boat hulls) on which to live, grow and reproduce. They attach to these surfaces using adhesive structures called byssal threads.

Zebra mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals and debris for food. This process can lead to increased water clarity and a depleted food supply for other aquatic organisms, including fish. The higher light penetration fosters growth of rooted aquatic plants which, although creating more habitat for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers and swimmers. Zebra mussel infestations may

also promote the growth of blue-green algae, since they avoid consuming this type of algae but not others.

Zebra mussels attach to the shells of native mussels in great masses, effectively smothering them. A survey by the Corps in the East Channel of the Mississippi River at Prairie du Chien revealed a substantial reduction in the diversity and density of native mussels due to Zebra Mussel infestations. The East Channel provides habitat for one of the best mussel beds in the Upper Mississippi River. Future efforts are being considered to relocate such native mussel beds to waters that are less likely to be impacted by zebra mussels.

Financial impacts have been significant to Wisconsin's water utilities and to power plants, where these animals congregate on and clog intake and distribution pipes. In 2001, for example, Wisconsin Electric Power Company reported that they were spending $1.2 million per year in the control of zebra mussels on their Lake Michigan power plants. Lock and dam operators on the Mississippi River and raw water users have also incurred costs. The estimated annual cost of controlling zebra mussels in the Great Lakes now range from $100 to $400 million, according to NOAA Great Lakes Environmental Research Laboratory Director Dr. Stephen Brandt.

CONTROLLING ZEBRA MUSSELS: Once zebra mussels are established in a water body, very little can be done to control them. **It is therefore crucial to take all possible measures to prevent their introduction in the first place.** Be sure to follow the four-step procedure in preventing the spread of aquatic hitchhikers. In addition to these measures, boaters can take specific precautions in protecting their motors from zebra mussels.

Infestation of raw water intake pipes and structures can seriously limit water flow into hatcheries, drinking water treatment plants, industrial facilities, and cooling systems of power plants. Virtually all control initiatives have stemmed from such utility or industrial infestations, thus cost-effectiveness and mechanical functioning are the primary goals. Control measures can include physical removal, industrial vacuums, backflushing, chemical applications (chlorine, bromine, potassium permanganate), and even oxygen deprivation. An ozonation process is under investigation (patented by Bollyky Associates Inc.) which involves the pumping of high concentrations of dissolved ozone into the intake of raw water pipes. This method only works in controlling veligers, and supposedly has little negative impacts on the ecosystem. Further research on effective industrial control measures that minimize negative impacts on ecosystem health is needed.

No selective method has been developed that succeeds in controlling zebra mussels in the wild without also harming other aquatic organisms. To a certain extent, ducks and fish will eat small zebra mussels, but not to the point of effectively controlling their populations. Water draw-downs may yield positive results in some situations, as the mussels are killed by deep freezing during winter. They are also susceptible to the scouring and freezing of winter ice along the

shores of the Great Lakes. As of yet, no practical and effective controls are known, again emphasizing the need for research and prevention.

Appendix E: Discussion of Aquatic Plant Management Options/Control Techniques

The following discussion involves techniques used to control the growth and distribution of aquatic plants, particularly Eurasian Water Milfoil. It should be thoroughly understood the application, location, timing and combination of treatment methods must be carefully considered to effectively manage aquatic plants. A summary table from the WI DNR for management options of aquatic plants is also included in this appendix.

Introduction

Taking inventory of the present situation in order to predict possible outcomes will prove vital in the decision making process of what control option(s) would be the most successful for Whitefish Lake. Also, it is in some instances preferable to choose a no action option for a short period of time to provide more time for further exploration and discussion of other control options.

Control of Eurasian watermilfoil is just that, “control.” It is unlikely that Eurasian watermilfoil can ever be eradicated from a lake once it is established. The Eurasian water milfoil in Whitefish lake is very limited at this time. Considering combinations of the following management options will likely increase the success of any Eurasian watermilfoil control.

Chemical Control

Chemical control uses herbicides to treat EWM infestations. Depending upon the application technique and management decisions, chemical control can be used as either a partial or whole lake treatment. However, given the size and morphology of Whitefish Lake whole lake treatments using chemicals is not a realistic option. There are two major types of herbicide commonly used to treat EWM infestations, systemic and contact herbicides.

Two forms of contact herbicides have been used to control Eurasian watermilfoil; Diquat and Endothall. Contact herbicides kill the plant tissue that it comes in contact with. This makes contact herbicides nonselective, and if too much plant material is killed it can cause anoxic conditions which can have negative impacts on the aquatic ecosystem. Diquat typically shows results within 6-10 days and is not as effective in silty or muddy waters. Also, certain water uses can be restricted from 24 hours to 14 days (i.e. fishing, swimming, water intake, etc).

Systemic herbicides, like 2,4-D or Fluridone, translocate throughout the entire plant and under ideal conditions can provide complete control of target weed. 2,4-D is somewhat

species specific and has been used to successfully control watermilfoil in our region, though no long term control has been shown. Soon after application 2,4-D is absorbed by the plants leaf and stem tissues and moves to the actively growing apical regions in the shoots and roots, killing the entire plant.

Fluridone is typically used on areas larger than 5 acres or full lake treatments. Species selectivity can be achieved by varying dosage amounts. It typically takes 30-40 days before results are seen. Fluridone also prevents anoxic conditions that are often associated with herbicide treatments. However, flow rates within the lake system must be known or the herbicide could be flushed out of the lake. Given Whitefish Lake's morphology it may not be appropriate to use Fluridone. It is also unclear whether or not long term control using Fluridone is successful.

The high cost of herbicides that is associated with continued re-application should be taken into consideration. Also, herbicide application techniques, time of application, and lake morphology play key roles in determining overall cost and success. Permits are required in Wisconsin to apply herbicides over water. Chemical spot treatments with 2,4-D has been done on EWM within Whitefish Lake in 2007 and on other area lakes with varied results. Most lakes have shown adequate control though eradication has not been possible using any chemical control.

Physical Control

Hand pulling

Pros	Cons
Very selective	Difficult work
Good for small infestations	Time & Labor Intensive
	Can cause fragmentation

Drawdown is a control option that has been used in Wisconsin and many other states to control Eurasian watermilfoil with moderate success. In order for a drawdown to be plausible a structure such as an impoundment or a dam needs to already be in place in order to drawdown the water level. For Northern Wisconsin the best time to do a drawdown for aquatic plant control would be during the winter so that the plant and its roots are exposed to extreme temperatures usually killing it. In some cases an overwinter drawdown can have long term effects or effects that can be seen for up to 2

years or more. If a structure is already in place it is relatively inexpensive to lower the water level. Also, it requires very little labor and time.

Some drawbacks to a drawdown are:

- Could have negative ecological impacts (i.e. fish and wildlife, non target aquatic plants)
- Not selective
- Weather factors play a key role in the success or failure
- Inconsistency of plant (Eurasian watermilfoil) response.
- Could have negative socioeconomic impacts. (i.e. people could dislike the low ice/water levels for recreation and/or aesthetic reasons.)
- If draw down does not occur semi-regularly recolonization will occur.
- Algal blooms have been reported to occur in response to drawdowns.

Benthic Barrier

Pros	Cons
Creates limited environmental disturbance	Can inhibit native plant growth for 1-2 years following removal.
Allow for selectivity of area	EWM can recolonize up to 50% of area in 1 month.
WDNR approval is required	Deep water infestations require scuba gear.
Good for small areas near docks.	Non-specific
	Not feasible for large areas.

Conventional Mechanical Harvesting Systems

Pros	Cons
Can select areas to open up (fishing & boating lanes).	Must be deeper than three feet with few stumps.
Can remove a lot of plant biomass in short amount of time.	Fragmentation
	Possible damage to shoreline and/or structures.
	If not properly maintained they can discharge oils and gases into lake..
	Not species specific.
	Costly ($125/hr and 40 hr min) $500-2500 / hectare.
	Could cause disturbance of historical artifacts.
	Cut stems sometimes grow back thicker.
	Needs to be done repeatedly.

Biological

Biological control is the use of parasitoid, predator, pathogen, antagonist, or competitor populations to suppress a pest population, making it less abundant and thus less damaging than it would otherwise be. The most commonly used biological control of Eurasian watermilfoil is the indigenous weevil, *Euhrychiopsis lecontei*

The milfoil weevil is native to our region and is hosted by native watermilfoils, especially northern watermilfoil, *Myriophyllum sibiricum*. The weevil spends its summers on watermilfoil plants where it completes the various stages of its life cycle, and overwinters in dry leaf litter along the shore.

The milfoil weevil is highly specific to watermilfoils, and research has shown that weevils that have been exposed to Eurasian watermilfoil prefer it over the native milfoils. The milfoil weevil has been shown to prevent growth of watermilfoil in laboratory and field settings and is often associated with numerous milfoil declines. It is, however, completely unpredictable as to the success of the milfoil weevil in a certain lake, but if milfoil weevil populations are successful at controlling Eurasian watermilfoil the weevil-milfoil relations will most likely become cyclic. Also, the weevils do not prefer deep areas, yet they do not need to be in close proximity to shore. It is difficult to maintain milfoil weevil populations, and the native plants must be competitive enough to push out the impacted Eurasian watermilfoil.

Pros	**Cons**
If successful, weevil-milfoil relations will become cyclic.	No clear picture of weevils presence in the Flowage.
Is compatible with other controls (chemical).	Does not like deep areas.
Yet does not need to be next to shore.	Difficult to maintain weevil populations
	Native plants must be competitive enough to replace EWM after weevils.
	Completely unpredictable as to success.
	Cost is around $1000 /1000 weevils and if no suitable population already exists.
	Life cycle differences.

Another form of biological control is introducing native aquatic plant species into the infested area to compete with the Eurasian watermilfoil. This option will most likely not work by itself and should be used in combination with other control options. Also special care should be taken when introducing even a native aquatic plant into an ecosystem.

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
No Management	N	Do not actively manage plants	Minimizing disturbance can protect native species that provide habitat for aquatic fauna; protecting natives may limit spread of invasive species; aquatic plants reduce shoreline erosion and may improve water clarity	May allow small population of invasive plants to become larger, more difficult to control later
			No immediate financial cost	Excessive plant growth can hamper navigation and recreational lake use
			No system disturbance	May require modification of lake users' behavior and perception
			No unintended effects of chemicals	
			Permit not required	
Mechanical Control	May be required under NR 109	Plants reduced by mechanical means	Flexible control	Must be repeated, often more than once per season
		Wide range of techniques, from manual to highly mechanized	Can balance habitat and recreational needs	Can suspend sediments and increase turbidity and nutrient release
a. Handpulling/Manual raking	Y/N	SCUBA divers or snorkelers remove plants by hand or plants are removed with a rake	Little to no damage done to lake or to native plant species	Very labor intensive
		Works best in soft sediments	Can be highly selective	Needs to be carefully monitored
			Can be done by shoreline property owners without permits within an area <30 ft wide OR where selectively removing exotics	Roots, runners, and even fragments of some species, particularly Eurasian watermilfoil (EWM) will start new plants, so all of plant must be removed
			Can be very effective at removing problem plants, particularly following early detection of an invasive exotic species	Small-scale control only

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
b. Harvesting	Y	Plants are "mowed" at depths of 2-5 ft, collected with a conveyor and off-loaded onto shore	Immediate results	Not selective in species removed
		Harvest invasives only if invasive is already present throughout the lake	EWM removed before it has the opportunity to autofragment, which may create more fragments than created by harvesting	Fragments of vegetation can re-root
			Minimal impact to lake ecology	Can remove some small fish and reptiles from lake
			Harvested lanes through dense weed beds can increase growth and survival of some fish	Initial cost of harvester expensive
			Can remove some nutrients from lake	
Biological Control	Y	Living organisms (e.g. insects or fungi) eat or infect plants	Self-sustaining; organism will over-winter, resume eating its host the next year	Effectiveness will vary as control agent's population fluctates
			Lowers density of problem plant to allow growth of natives	Provides moderate control - complete control unlikely
				Control response may be slow
				Must have enough control agent to be effective
a. Weevils on EWM	Y	Native weevil prefers EWM to other native water-milfoil	Native to Wisconsin: weevil cannot "escape" and become a problem	Need to stock large numbers, even if some already present
			Selective control of target species	Need good habitat for overwintering on shore (leaf litter) associated with undeveloped shorelines
			Longer-term control with limited management	Bluegill populations decrease densities through predation

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Pathogens	Y	Fungal/bacterial/viral pathogen introduced to target species to induce mortalitiy	May be species specific	Largely experimental; effectiveness and longevity unknown
				May provide long-term control	Possible side effects not understood
				Few dangers to humans or animals	
c.	Allelopathy	Y	Aquatic plants release chemical compounds that inhibit other plants from growing	May provide long-term, maintenance-free control	Initial transplanting slow and labor-intensive
				Spikerushes (*Eleocharis* spp.) appear to inhibit Eurasian watermilfoil growth	Spikerushes native to WI, and have not effectively limited EWM growth
					Wave action along shore makes it difficult to establish plants; plants will not grow in deep or turbid water
d.	Planting native plants	Y	Diverse native plant community established to repel invasive species	Native plants provide food and habitat for aquatic fauna	Initial transplanting slow and labor-intensive
				Diverse native community may be "resistant" to invasive species	Nuisance invasive plants may outcompete plantings
				Supplements removal techniques	Largely experimental; few well-documented cases
					If transplants from external sources (another lake or nursury), may include additional invasive species or "hitchhikers"

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
Physical Control	Required under Ch. 30 / NR 107	Plants are reduced by altering variables that affect growth, such as water depth or light levels		
a. Fabrics/ Bottom Barriers	Y	Prevents light from getting to lake bottom	Reduces turbidity in soft-substrate areas	Eliminates all plants, including native plants important for a healthy lake ecosystem
			Useful for small areas	May inhibit spawning by some fish
				Need maintenance or will become covered in sediment and ineffective
				Gas accumulation under blankets can cause them to dislodge from the bottom
				Affects benthic invertebrates
				Anaerobic environment forms that can release excessive nutrients from sediment
b. Drawdown	Y, May require Environmental Assessment	Lake water lowered with siphon or water level control device; plants killed when sediment dries, compacts or freezes	Winter drawdown can be effective at restoration, provided drying and freezing occur. Sediment compaction is possible over winter	Plants with large seed bank or propagules that survive drawdown may become more abundant upon refilling
		Season or duration of drawdown can change effects	Summer drawdown can restore large portions of shoreline and shallow areas as well as provide sediment compaction	May impact attached wetlands and shallow wells near shore
			Emergent plant species often rebound near shore providing fish and wildlife habitat, sediment stabilization, and increased water quality	Species growing in deep water (e.g. EWM) that survive may increase, particularly if desirable native species are reduced
			Success demonstrated for reducing EWM, variable success for curly-leaf pondweed (CLP)	Can affect fish, particularly in shallow lakes if oxygen levels drop or if water levels are not restored before spring spawning
			Restores natural water fluctuation important for all aquatic ecosystems	Winter drawdawn must start in early fall or will kill hibernating reptiles and amphibians
				Navigation and use of lake is limited during drawdown

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
c.	Dredging	Y	Plants are removed along with sediment	Increases water depth	Severe impact on lake ecosystem
			Most effective when soft sediments overlay harder substrate	Removes nutrient rich sediments	Increases turbidity and releases nutrients
			For extremely impacted systems	Removes soft bottom sediments that may have high oxygen demand	Exposed sediments may be recolonized by invasive species
			Extensive planning required		Sediment testing may be necessary
					Removes benthic organisms
					Dredged materials must be disposed of
d.	Dyes	Y	Colors water, reducing light and reducing plant and algal growth	Impairs plant growth without increasing turbidity	Appropriate for very small water bodies
				Usually non-toxic, degrades naturally over a few weeks	Should not be used in pond or lake with outflow
					Impairs aesthetics
					Effects to microscopic organisms unknown
e.	Non-point source nutrient control	N	Runoff of nutrients from the watershed are reduced (e.g. by controlling construction erosion or reducing fertilizer use) thereby providing fewer nutrients available for plant growth	Attempts to correct source of problem, not treat symptoms	Results can take years to be evident due to internal recycling of already-present lake nutrients
				Could improve water clarity and reduce occurrences of algal blooms	Requires landowner cooperation and regulation
				Native plants may be able to better compete with invasive species in low-nutrient conditions	Improved water clarity may increase plant growth

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
Chemical Control	Y, Required under NR 107	Granules or liquid chemicals kill plants or cease plant growth; some chemicals used primarily for algae	Some flexibility for different situations	Possible toxicity to aquatic animals or humans, especially applicators
		Results usually within 10 days of treatment, but repeat treatments usually needed	Some can be selective if applied correctly	May kill desirable plant species, e.g. native water-milfoil or native pondweeds; maintaining healthy native plants important for lake ecology and minimizing spread of invasives
		Chemicals must be used in accordance with label guidelines and restrictions	Can be used for restoration activities	Treatment set-back requirements from potable water sources and/or drinking water use restrictions after application, usually based on concentration
				May cause severe drop in dissolved oxygen causing fish kill, depends on plant biomass killed, temperatures and lake size and shape
				Often controversial
a. 2,4-D	Y	Systemic[1] herbicide selective to broadleaf[2] plants that inhibits cell division in new tissue	Moderately to highly effective, especially on EWM	May cause oxygen depletion after plants die and decompose
		Applied as liquid or granules during early growth phase	Monocots, such as pondweeds (e.g. CLP) and many other native species not affected	May kill native dicots such as pond lilies and other submerged species (e.g. coontail)
			Can be selective depending on concentration and seasonal timing	Cannot be used in combination with copper herbicides (used for algae)
			Can be used in synergy with endotholl for early season CLP and EWM treatments	Toxic to fish
			Widely used aquatic herbicide	

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Endothall	Y	Broad-spectrum[3], contact[4] herbicide that inhibits protein synthesis	Especially effective on CLP and also effective on EWM	Kills many native pondweeds
			Applied as liquid or granules	May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring	Not as effective in dense plant beds; heavy vegetation requires multiple treatments
				Can be selective depending on concentration and seasonal timing	Not to be used in water supplies; post-treatment restriction on irrigation
				Can be combined with 2,4-D for early season CLP and EWM treatments, or with copper compounds	Toxic to aquatic fauna (to varying degrees)
				Limited off-site drift	
c.	Diquat	Y	Broad-spectrum, contact herbicide that disrupts cellular functioning	Mostly used for water-milfoil and duckweed	May impact non-target plants, especially native pondweeds, coontail, elodea, naiads
			Applied as liquid, can be combined with copper treatment	Rapid action	Toxic to aquatic invertebrates
				Limited direct toxicity on fish and other animals	Must be reapplied several years in a row
					Ineffective in muddy or cold water (<50°F)
d.	Fluridone	Y; special permit and Environmental Assessment may be required	Broad-spectrum, systemic herbicide that inhibits photosynthesis	Effective on EWM for 1 to 4 years with aggressive follow-up treatments	Affects non-target plants, particularly native milfoils, coontails, elodea, and naiads, even at low concentrations
			Must be applied during early growth stage	Some reduction in non-target effects can be achieved by lowering dosage	Requires long contact time at low doses: 60-90 days
			Available with a special permit only; chemical applications beyond 150 ft from shore not allowed under NR 107	Slow decomposition of plants may limit decreases in dissolved oxygen	Demonstrated herbicide resistance in hydrilla subjected to repeat treatments
			Applied at very low concentration at whole lake scale	Low toxicity to aquatic animals	In shallow eutrophic systems, may result in decreased water clarity
					Unknown effect of repeat whole-lake treatments on lake ecology

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
e.	Glyphosate	Y	Broad-spectrum, systemic herbicide that disrupts enzyme formation and function	Effective on floating and emergent plants such as purple loosestrife	RoundUp is often incorrectly substituted for Rodeo - Associated surfactants of RoundUp believed to be toxic to reptiles and amphibians
			Usually used for purple loosestrife stems or cattails	Selective if carefully applied to individual plants	Cannot be used near potable water intakes
			Applied as liquid spray or painted on loosetrife stems	Non-toxic to most aquatic animals at recommended dosages	Ineffective in muddy water
				Effective control for 1-5 years	No control of submerged plants
f.	Triclopyr	Y	Systemic herbicide selective to broadleaf plants that disrupts enzyme function	Effective on many emergent and floating plants	Impacts may occur to some native plants at higher doses (e.g. coontail)
			Applied as liquid spray or liquid	More effective on dicots, such as purple loosestrife; may be more effective than glyphosate	May be toxic to sensitive invertebrates at higher concentrations
				Control of target plants occurs in 3-5 weeks	Retreatment opportunities may be limited due to maximum seasonal rate (2.5 ppm)
				Low toxicity to aquatic animals	Sensitive to UV light; sunlight can break herbicide down prematurely
				No recreational use restrictions following treatment	Relatively new management option for aquatic plants (since 2003)
g.	Copper compounds	Y	Broad-spectrum, systemic herbicide that prevents photosynthesis	Reduces algal growth and increases water clarity	Elemental copper accumulates and persists in sediments
			Used to control planktonic and filamentous algae	No recreational or agricultural restrictions on water use following treatment	Short-term results
			Wisconsin allows small-scale control only	Herbicidal action on hydrilla, an invasive plant not yet present in Wisconsin	Long-term effects of repeat treatments to benthic organisms unknown
					Toxic to invertebrates, trout and other fish, depending on the hardness of the water
					Clear water may increase plant growth

[1]Systemic herbicide - Must be absorbed by the plant and moved to the site of action. Often slower-acting than contact herbicides.

[2]Broadleaf herbicide - Affects only dicots, one of two groups of plants. Aquatic dicots include waterlilies, bladderworts, watermilfoils, and coontails.

[3]Broad-spectrum herbicide - Affects both monocots and dicots.

[4]Contact herbicide - Unable to move within the plant; kills only plant tissue it contacts directly.

Specific effects of herbicide treatments dependent on timing, dosage, duration of treatment, and location.

References to registered products are for your convenience and not intended as an endorsement or criticism of that product versus other similar products.

This document is intended to be a guide to available aquatic plant control techniques, and is not necessarily an exhaustive list.

Please contact your local Aquatic Plant Management Specialist when considering a permit.

Appendix F: WI DNR Pre and Post Treatment MonitoringProtocol

Pre and Post AIS Chemical Herbicide Treatment Monitoring

(May 2007)

Purpose

This protocol is used to determine the need for, and evaluate the results of herbicide application to reduce aquatic invasive plant species. The following protocol is applicable for introducing new treatments to lakes where the treatment size is greater than 10 acres or greater than 10% of the lake littoral area and more than 150 feet from shore as well as any AIS grant funded treatments or where performance results are needed where restoration is a goal i.e. for science or for financial accountability. This protocol is written for Eurasian water-milfoil (EWM) but can be adapted for Curly-leaf Pondweed and other AIS. This protocol may be appropriately adapted to evaluate non-herbicide controls. The adaptation will retain the goal of science and financial accountability of AIS grant funded projects.

Proposed treatment surveys. To determine:

- Target areas where EWM is found and within which treatment is proposed for a conditional APM permit
- Target and native species presence/absence and abundance.

Pre-treatment surveys. To determine:

- The extent of the AIS both in distribution and density – refinement of proposed treatment areas.
- The need for an herbicide treatment or whether another method of control is more appropriate at this time.
- Cost of treatment both in product and labor.
- Proper acreage for permit conditions and public notice.
- Adjustments in application rates based on proximity to native plants.

Post-treatment surveys: To determine:

- The effectiveness of the herbicide application, both in density and distribution.
- If herbicide is the desired control method.
- The response of native plants.
- If adjustments need to be made to application rates.
- Future direction of plant management activities

Protocol for Established Infestations

Base YR

Recent (within 5 years) summer point/intercept (P/I) survey to characterize entire plant community and identify potential treatment areas.

YR 1 Season before treatment (may be base year)

1. *Proposed treatment survey.*
    a. During the summer growing season map areas as polygons using GPS to outline beds and pinpoint individual target plants.
        i. The initial Point/Intercept survey is unlikely to identify every stand of EWM. The sponsor or applicant must use additional, less formal strategies to find stands of this invasive such as:
            1. Define beds by sub-sampling with a rake at greater frequencies (to determine presence only around the points where target plants were found).

2. If clarity is good (to the depth of rooted plants) and bed is topped out, identification can be visual but thoroughly augmented with rake tosses to verify species.
3. For lower clarity waters, sub sample with a rake on a series of denser points. Augmenting with scuba and underwater video is highly recommended.
4. Boat or walk around the shoreline looking for the invasive in the shallow water areas. EWM is less likely to be found on hard sediments, but may occur anywhere.
5. Look for plant fragments wind-rowed on shore as indication plants floated in from further off shore.
6. When trying to see into the water, use brown polarized sun glasses or use an Aqua-View Scope.

b. Confirm EWM with vouchers, 1 per large (> 5 acres) treatment area or polygon or site visit by DNR personnel (who should also voucher).
c. In order to assess the effect of chemical treatment on natives, there must be a survey of <u>all</u> plant species before treatment. However, since natives will be largely absent at the time of the spring pre-treatment survey, the natives must be assessed the summer before treatment. Therefore, after defining the proposed treatment polygons (1a), perform a presence/absence and rake fullness assessment of all plants at a sub sample of points within and near the polygons determined by:
    i. A reference table. Sample polygons greater than 5 acres unless the proposed treatment areas are smaller than 5 acres

Acres of Polygon	# of Sampling Points
0.50	1
1.00	4
2.00	8
3.00	12
4.00	16
5.00	20
7.00	28
10.00	40
15.00	60
20.00	80
30.00	120
40.00	160
50.00	200

<u>YR 2 First treatment</u>

2. *Pre-treatment Survey*
    a. Using the established *proposed treatment* polygons from YR 1, repeat the methods in proposed treatment survey as needed sampling only for EWM to confirm the appropriateness of the treatment area. Plants will be small, and may be very sparse this time of year. Underwater visual/video of the middle and edges of the proposed polygon is highly recommended.

3. CONDUCT TREATMENT after the target specie is actively growing but before native species are active. Generally, this will be prior to water temp of 60 degrees F. Best results are generally obtained when biomass is still low, thus earlier treatment within the treatment time window is better than later.

4. *Post-treatment Survey*. Conducted at least four weeks after treatment For CLP, post treatment survey needs to be completed before CLP seasonal growth ends. For EWM, post treatment should be delayed until native plants are well established, generally during mid-July-mid-August. For the summer post-treatment survey, repeat steps 1.c. This will be used to identify effectiveness on target plants, determine if there was any harm or benefits to native plants and identify next year's potential treatment areas for target plants.
    a. Compare summer surveys. If there are chemical treatments in subsequent years, compare summer surveys for treatment effects on natives and long-term effects on target species.

5. Conduct visual survey to look for new colonies.

YR3 and Yr 4

6. Repeat YR 2 procedure. Be sure to resample all areas treated in all years even if treatment area declines in size over time so that an accurate record of control ***and results*** can be established.

YR 5

7. Repeat YR 2 procedure if necessary.
8. Conduct a lake wide P/I survey (repeat base year) to gauge overall lake community response.

Notes :

Summer to summer post treatment comparison is for assessing native and target species response. Conversely spring to spring is for assessing target AIS response. Comparing spring to fall in the same year is not a valid assessment of native response. A fall survey may be added, however, to locate potential new EWM spring treatment areas.

Once established and repeated monitoring indicates that the beds of target species stay in the same location year to year and only density varies, pre-treatment surveys on repeated nuisance control treatments may be less rigorous.

During initial P/I survey of lake, assess weevil damage, northern water milfoil abundance and shoreland habitat and consider need for treatment or scale of treatment given bio-control potential. Use CLMN (Herman) guidance on weevil monitoring.

The plant surveys should be conducted by an independent party not directly affiliated with the herbicide applicator to prevent bias or appearance of bias.

Measuring success or the need to change course.

- Chose a percent decrease in the target plant area coverage or frequency of occurrence for an annual goal of at least 50% for restoration projects.
- For an overall long term goal, a reduction to less than large scale treatment (less than 10 acres or 10% of lake littoral area) where annual spot treatments can sustain low

level occurrences is reasonable. Alternatively, a goal of reducing dense beds to scattered plants using a density measurement might be appropriate.

- Acceptable native response is no net loss and ideally some gain. However, some loss may be purely sampling variance or inter-annual variation.

Appendix G: Shoreline Assessment Protocol

Sand Lake Shoreline Asssessment Survey Protocol

Goal: Determine the composition of the shoreline and the 35 foot buffer

Uses

1. Correlate if possible the conditions of buffer and water quality
2. Targeted property owner education about advantages of buffers
3. Identify egregious conditions on the lake shore
4. Support for grant applications if appropriate
5. Reference if a landowner takes future action adverse to local regulations

Procedure

Tour the shoreline in a boat taking pictures of the lake shore parcels, determining the composition of the shoreline and buffer. A buffer with native plants is the most positive for water quality. The objective is to determine within the 35 foot buffer the square footage of impervious surfaces, cleared areas, natural areas and the like.

Communicate

Communicate to the property owners that the survey will be taken and reasons for it. There may be some anxiety that the survey will be used sole for enforcement. Deal with this fear in the communications.

Steps

1. Get from the county mapping a map of the lake shore by section showing parcel #'s
2. If possible get from the county mapping an aerial map by section with parcel boundaries drawn in.
3. Get from the county mapping the parcel numbers if not already on the maps.
4. Get from the county the names of the property owners. Note the property owners will change over time. The parcel numbers do not change. However, to help identify the parcel from the boat, it helps to know the current property owner.
5. Using Excel or similar program, construct spread sheet for each map section. Log into the spread sheet the parcel numbers and owner names.
6. Using a ruler and scale on maps estimate the shoreline length, record this on spread sheet. As an accuracy check contact a number of property owners to verify their lake frontage. Adjust lake shore estimation process as needed.

7. Round up several people to do the survey. Skills at estimating distances and dimensions are important. For consistency, it is better to have a limited number of people to do the survey.
8. Select several properties that contain structures and cleared areas in the buffer. From the boat estimate the dimensions and distances. On land, measure areas and distances estimated. Repeat this process until the ability to estimate gets reasonably accurate.
9. It may be possible to borrow from the County Land and Water a laser tool that measures distances.
10. Tour the lake with someone who knows the properties and owners for that section of the lake. It is important to have people in the boat who can associate the owner name with parcel as seen from the lake. Take pictures of the parcel and note picture numbers, shoreline composition and what is in the buffer on the spreadsheet that was developed in step 5. You can refer to the pictures later to verify what was noted. Take your time. It can get a little frustrating. It works best to have one person driving the boat, one person taking the pictures and calling out the picture number and one person to record the data.
11. Log data into the computer Excel spread sheet by section.
12. Not all will go as planned. If there are problems with matching parcels, pictures and names or determining the shoreline and buffer composition. It may be necessary to visit the property. Look up the owner in the phone book or get the fire number of the parcel from the county. Call before visiting the property.
13. Produce an Excel summary of the lake by section. Review the result of the work with the County Land and Water Conservation Department.
14. It goes without saying this is a lot of work. Back up your data and pictures frequently.
15. Create a CD or DVD of the pictures and spread sheets. Keep one in a safe place. Distribute copies to those that need them.

Spreadsheet Data Elements

General	Shoreline in feet	Buffer in square feet	Other data
Parcel number	Total	Total	Elevation of buffer
Property owner	Natural vegetation	Natural	Non conforming structures
Picture number	Natural Sand	Impervious surfaces	Log in the water
	Natural Rock	Cleared	Comments

	RipRap Structures Lawn Sand hauled in Other as needed	Lawn Sand Other as needed	

Spreadsheet Data Element Descriptions

Shoreline

This is the condition of the shoreline where the water meets the land at the ordinary water level.

Natural	At the water's edge there is natural vegetation. If there is a small strip of sand say less than one foot, before the vegetation, call it natural vegetation
Sand	Either natural or man-made beach
Rock	A natural rock shoreline
RipRap	Rock put there by man
Structures	Man made impervious surfaces such as boat launches or boat houses. Column heading "Struct"
Lawn	Obviously planted or natural that is routinely mowed

Note it may not be necessary to use all the specific categories for the shoreline. Get advice from the users the DNR and others. Check with the DNR Lakes management person.

Buffer

This is the area from the shoreline to 35 feet into the property

Natural	Just that trees, brush and other vegetation that is natural

Hard Surfaces	Can be boat houses, boat launches, house roofs, decks and the like. Anything that prevents rain water from soaking into the soil. Open stairs are considered cleared. Column heading "Hard Surf"
Cleared	An area that is primarily cleared but not mowed. It could contain a few trees or shrubs. Include open stairs here.
Lawn	Grass or vegetation that is obviously mowed.
Sand	Natural sand or a sand hauled in

Other Data

Elevation	Three categories should be enough; s=steep, m=moderate, f= mostly flat. Column heading "Elv"
Non Conform	Structures such as storage sheds, boat houses and residences that are within the 75 foot set back. Column heading " Non Stru"
Comments	Any comments of interest such as erosion, junk and the like.

Appendix H: WDNR Point-Intercept Survey Aquatic Plant Sampling Protocol

Protocol for Aquatic Plant Survey
Collecting, Mapping, Preserving and Data Entry

Below we outline the protocol for statewide baseline sampling of aquatic macrophytes, with the primary goals of 1) comparing year-to-year data within a lake, and 2) comparing data among lakes. We describe a formal quantitative survey conducted at pre-determined sampling locations distributed evenly over the lake surface (point-intercept approach). We believe that this method, when combined with a boat survey to gather additional information on areas not sampled directly, will best characterize a lake's plant community. The chief benefit of adopting a statewide protocol is that variation in the sample set can be primarily attributed to actual differences in plant communities, instead of the confounding variables introduced by using different sampling techniques.

These guidelines are intended to work on most lakes. However, modifications may be required if a lake is uniquely shaped so that a uniform distribution of points isn't representative (long, skinny lake shape), or if obtaining rake samples is difficult due to substrate (rocky/cobble bottom).

Please note these are "baseline" recommendations. Additional monitoring activities may be warranted if the goal is to assess a specific management activity. For example, to gauge the success of chemical spot-treating stands of an exotic species in a relatively large lake, we recommend additional mapping of the beds within a season before and after treatment.

The baseline sampling described below should be conducted between early July and mid August. Although changes (such as biomass) in the plant community through this long sampling window might complicate data interpretation, in this survey we are mostly interested in species diversity and frequency, variables that should be fairly constant through the growing season. However, as described below, field workers are asked to assess rake fullness for all species and these ratings will likely vary with sample date. For many species, including Eurasian water-milfoil, plant biomass and density will probably increase as the season progresses. Narrow-leaved pondweeds begin to disappear by mid-August. Data for these species must be interpreted carefully with the sampling date in mind.

Curly-leaf pondweed (CLP) creates a special problem because it is often gone before the recommended sampling window between early July and mid-August. If you have any suspicion that CLP is present but not found when sampled, be sure to talk to APM staff to work out the best sampling scheme.

DNR personnel and groups using state money (e.g. planning, protection or aquatic invasive species grants) must follow this protocol.

I. Field Equipment

1. Required field equipment: boat, handheld GPS unit with WAAS (Wide Area Augmentation System) capability (with site locations already loaded, Garmin 76 is a commonly used model within DNR), a lake map, waterproof field data sheets, pole-mounted rake, weighted rake on a rope, depth finder, storage bags for vouchered specimens, personal flotation device.

2. Recommended equipment (helpful, but not necessary): trolling motor, underwater video camera, plant ID references, hand lens, cooler for storing samples, digital camera to document shoreline features (e.g., deadfall, dock, house) for sample points near shore that will provide a visual complement to a dot on a map, waterproof paper tags and/or Sharpie for labeling bags with vouchers and unknown plant species.

II. Point Intercept Sampling Method

1. Description

We require the following point-intercept sampling protocol. In this method, a large number of sampling sites are distributed in a grid across the lake. There are several benefits to a grid sampling design. An evenly spaced distribution of points results in a good overview of the entire lake. It is easy to replicate, and it is easy to preserve and present the spatial information. Please contact Jen Hauxwell (Jennifer.Hauxwell@dnr.state.wi.us) with lake name, county, water body identification code (WBIC), and any other depth and plant information available so that she can establish sampling points for the lake.

The size of the littoral zone and shape of the lake determines the number of points and the grid resolution. You will receive an electronic file of sampling points to upload into a GPS unit (below). Once on the lake, you will go to each site and collect plants and data as described below.

2. Uploading sampling points to the GPS unit

The following step-by-step instructions were adapted from the WIDNR Garmin GPS Tool User Manual v. 8.2.5, available to DNR employees on the intranet.
file:///%5C%5Ccentral%5Cet_apps%5CPROD%5CWiDNR_Garmin%5Cstandalone_garmin%5CDEV_Doc%5CWIDNR_Garmin_Standalone_GPS_Tool_User_Guide.pdf
This is a two step process. First you need to *_load_* the sample points you receive from Jen Hauxwell in a text file into the WIDNR Garmin GPS Tool, a computer file. Second you need to *_upload_* the points from your computer onto the GPS unit itself. For more information or troubleshooting help consult the User Manual.

Please note that GPS units vary in how many way points they can store. In the event that the number of sampling points exceeds your unit's storage capacity, simply split the text

file containing the point information into multiple files. Upload successive files of points as needed.
(For more information on Garmin GPS units, please see http://www.garmin.com/ and navigate to consumer/outdoor/GPS mapping. Choose a unit and then click on "specifications" and, under navigation features, find the number of waypoints/icons.)

To upload points into your GPS unit from a text file (.txt) using the WIDNR Garmin GPS Tool you will need:

- **PC/laptop with WIDNR Garmin GPS Tool software**. If you do not have the software on your computer contact your administrator for installation.

- **Waypoint .txt file** in the same format as one created by the WI DNR Garmin GPS Tool. Text files received from DNR Research will be in the correct format.

- **PC Interface cable**. Comes standard with the GPS unit, or can be ordered at http://www.garmin.com/outdoor/products.html#mapping.

- **GPS unit with external data port.**

Step 1: SET "SIMULATING GPS" MODE

You must operate the Garmin GPS receiver in Simulating GPS mode while uploading/downloading data, so that the receiver is not trying to acquire satellite data during these activities. Check your GPS manual to determine how to do this. Instructions for the GPSMap 76 are given below.

1. Press and hold the [ON/OFF] button for two seconds to turn the GPS receiver on.

2. Several informational screens will display. Press the [PAGE] button until the first Acquiring Satellites screen appears.

3. Press the [MENU] button and select Start Simulator to see the Simulating GPS page.

Step 2: SET SERIAL DATA FORMAT

You must set the serial data format to GARMIN prior to transferring data. Failure to set the serial data format to GARMIN will cause a communication error between the WIDNR Garmin Tool and the GPS unit. Instructions for a GPSMap 76 are given below.

1. Press the [MENU] button twice, use the rocker key to select Setup, and then press [ENTER].

2. Use the rocker key to scroll left or right until the Interface tab is highlighted. Use the rocker key to scroll down to highlight the drop-down box and press [ENTER].

3. A menu will appear; select GARMIN and [ENTER]. Press [QUIT] twice to return to the main screen.

Step 3: PLUG IN THE PC INTERFACE CABLE

1. Plug the 9-pin serial connector into COM port #1 on your PC. If port #1 is in use, plug into the next available port, and note the port number. The WIDNR Garmin GPS Tool does not support connection through a USB port.

2. Plug the round end of the cable into the external data/auxiliary power port on the back of the GPS receiver. Check your GPS manual if you do not know where the data port is located. The GPS receiver should be on and in "simulating GPS" mode.

Step 4: LOAD WAYPOINT DATA FROM A TEXT FILE TO THE WIDNR GARMIN GPS TOOL

1. Open the WIDNR Garmin GPS Tool file on computer. Select the WIDNR Garmin GPS Tool > File > Load > Waypoints From > GPS Text File option.

2. Enter/Select the path and name of the text file to load into the Open window. The GPS data will be loaded into the WIDNR Garmin GPS Tool. If you have trouble at this point, see the next section on troubleshooting. Otherwise, go on to section 4, Waypoints.

3. Troubleshooting. If you encounter problems during loading, a pop-up window will notify the user. Click OK.

    a. If problems are encountered, check that the COM port is set correctly: GPS > Assign Port > select correct port #.

    b. Also check that the baud rate matches that of the GPS unit: GPS > Assign Port > Baud Rate > select correct rate. A GPSMap 76 will transfer at 9600.

    c. Check that the Serial Data Format is set to GARMIN (outlined in Step 2).

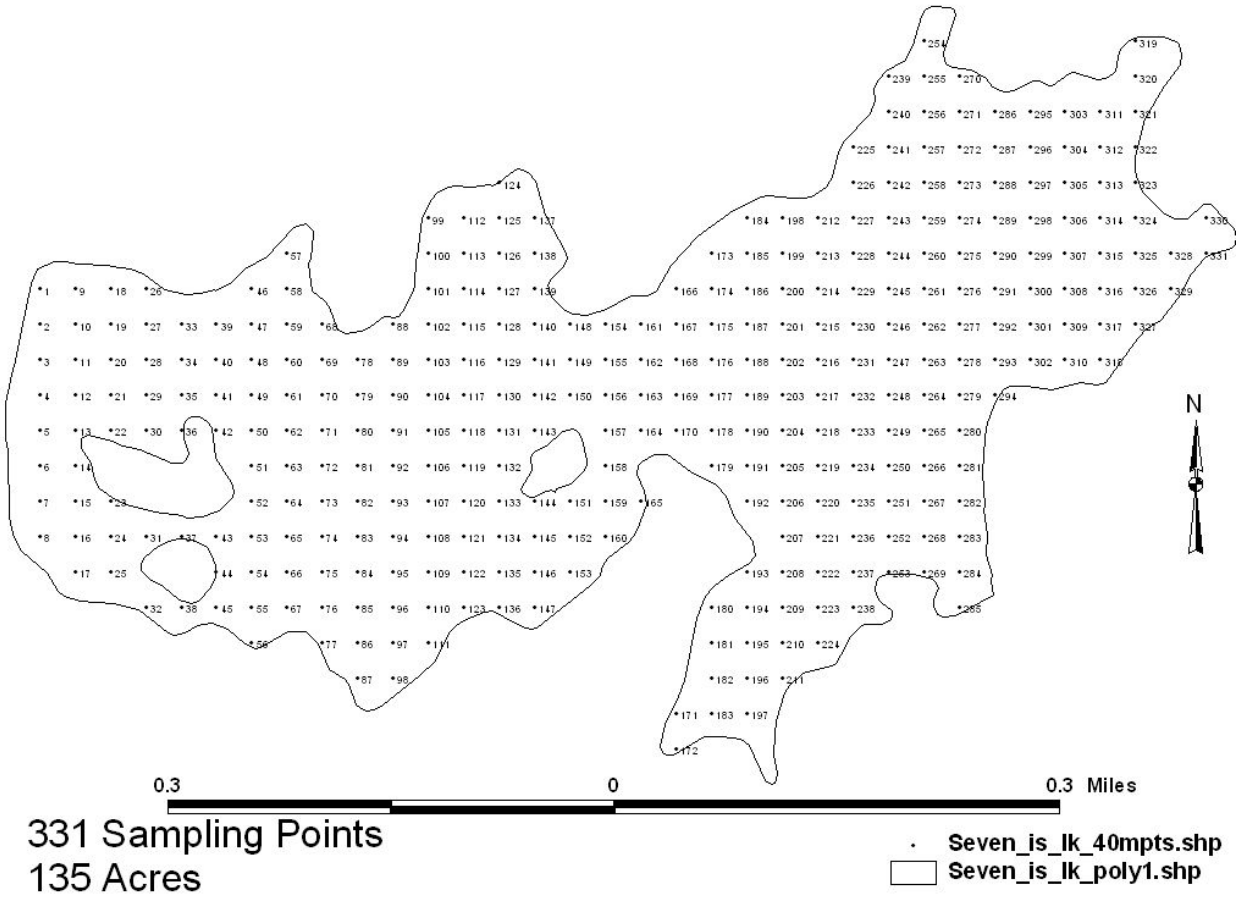
4. Waypoints. You can now view/edit waypoints by clicking the [Advanced] button on the WIDNR Garmin GPS Tool window.

Step 5: UPLOAD WAYPOINT DATA TO THE GPS RECEIVER

1. Select the WIDNR Garmin GPS Tool > Waypoint > Upload option.

2. When complete, the number of uploaded points appears at the bottom of the Garmin GPS Tool window. A pop-up window also indicates the number of waypoints successfully uploaded. Click OK. The uploaded waypoints should now be visible on the GPS receiver's Waypoints display.

3. Below is an example of lake with waypoints.



III. Collecting and Recording Plant Data

1. The rake sampler. The rake is constructed of two rake heads (double rake head) welded together, measuring 13.8 inches (35 centimeters) long with 14 teeth on each side. The handle is 8 ft (2.4 meters) in length, and should include a telescoping extension that results in a total handle length (from tip of rake head to fully extended end) of 15 feet (4.6 meters). You will also need a second, weighted, double rake head on a rope (rake-on-a-rope) to sample deeper sites. See section on "rake construction" for more detail.

2. Using the rake. Collect one rake sample per site: In waters less than 12 feet, handle the rake using the pole. In deeper water, toss the rake-on-a-rope. In either case, try to drag the rake along the bottom for 2.5 feet (0.75 meters). The amount of plants brought up on the rake may vary tremendously. Record each species present and estimate the rake fullness rating (more fully described). Keep two examples of each species found in the lake (see *7. Collect voucher samples* below). The rake may dislodge plants that will float to the surface, especially short rosette species not easily caught in the rake tines. Record each species present and estimate the rake fullness rating just as you would plants brought up on the rake

3. Point-intercept sampling issues and procedures.

a. Under-sampling near shore. One problem with the grid system is that it may under-sample very shallow sites where the vegetation is often quite different, even from sites just a bit deeper. To compensate for this problem, it is essential that you visit bays and shoreline areas missed by the grid and use the rake to collect and identify. Record any species seen, especially emergent vegetation (rooted in water), and describe near-shore habitats on the Boat Survey sheet. These data will not be tallied in the ENTRY or STATS pages but should be recorded on an electronic version of the Boat Survey Sheet to accompany the other data.

b. Navigational error. When navigating to sites using a handheld GPS unit, remember that there will be inherent error in locating points, sometimes as great as 60 feet. In addition to that error, there remains the question of "How close to the point is close enough?" You will almost never be able to sample a point at 0 feet from the point. Total error from the GPS error and navigational error *combined* should not exceed half of the sampling resolution. To avoid this when navigating using the map screen, navigate at no more than an 80-foot zoom level and completely cover the point with the arrow. At this level, the locational arrow on the screen is ~8 m long. This means that to sample with acceptable accuracy, the arrow must completely cover the point you are trying to hit, with the arrow centered over the point. At coarser zoom – 120-foot and up, even if you are completely covering the point you still may be quite far from the point, just because the arrow is so large in comparison to the size of the points. You may need to navigate at a greater zoom resolution, but, as you approach the target point, switch to the 80-ft zoom resolution to assure you hit your point accurately.

c. Hard-to-reach points. It may be hard to get to some sampling sites, especially in certain bays, where the water is very shallow and the substrate is mucky. When possible and practical, try to get to the point by poling with an oar, but do not spend undue time poling to these shallow sites. Due to safety concerns, field workers should not get out and drag the boat through mucky sediment to reach a site. If the sampling site is shallow but the substrate is firm, you should walk to the site from shore. If you cannot access a site, leave the depth blank and record NA (no access) or "land" (if the site is on land) in the comments column. (Remember to transfer these comments to the ENTRY sheet).

4. Filling out the Field Data sheet. Print the FIELD DATA sheet from the Excel workbook APMstats123.xls for use in the field. We recommend printing the data sheet onto waterproof paper such as Xerox Never Tear Paper.

a. Top portion. Fill out the top portion of the Field sheet with lake name, WBIC, county, and date. Also, record all the observers and how many hours they worked on this lake.

b. Site Number. Each site location is defined by the lat/long data imported onto your GPS unit and each site should have one row of data.

c. Depth. Measure and record the depth at each site sampled, regardless of whether vegetation is present. It is often easiest to mark the pole to establish depth for the shallower sites. However, a variety of options exist for taking depth measurements, including SONAR guns, depth finders that attach to the boat, or depth increments marked on the rope attached to the weighted rake sampler. If using a depth finder, please note that the accuracy decreases greatly in densely vegetated areas—depth will often be given to the top of the vegetation instead of to the lake bottom.

d. Dominant sediment type: Record sediment type (based on how the rake feels when in contact with the bottom) at each site where plants are sampled as: mucky (M), sandy (S), or rocky (R).

e. Pole vs. rope. Record whether the field team held the rake by the pole (P) or rope (R).

f. Species information. Note that the field data entry sheet does not include any species names, except for EWM (Eurasian water-milfoil) and CLP (curly-leaf pondweed). The sampling team must enter the species name the first time that species is encountered. Names will have to be entered again on successive field sheets (as they are encountered). The use of standard abbreviations can greatly shorten this process.

For all species, record the rake fullness rating (1- few, 2- moderate, 3-abundant, see illustration following this text) on the field data entry sheet at each sampling point where it is found. Record rake fullness for filamentous algae as well. Record the rake fullness rating for plants dislodged by, but not collected on the rake (please see "Under-sampling near shore", above). While at a site, look for any other plants (not already recorded) at that site within 6 ft (2m) of the boat. Record these species as a "visual" (V) on the data sheet. These species will be included in total number of species seen but will not be included in summary statistics. Account for plant parts that dangle or trail from the rake tines as if they were fully wrapped around the rake head.

5. Filling out the Boat Survey Data sheet. Often there will be localized occurrences of certain species (e.g., floating-leaf or emergent species) that are obvious to the viewer but could possibly be missed by the point-intercept grid. As discussed above in "Under-sampling near shore", you should examine shoreline areas that are out of the grid. While you need not make a separate trip around the entire lake, do visit areas that may be under-sampled and record the information (including the closest sampling point) on the Boat Survey (see APMstats123.xls) and on a lake map. Be sure to create an electronic version of the Boat Survey from the field notes.

6. If no plants are found. If no plants are found at a sampling site while approaching a deep section in the lake, record the depth but do not record any species information. Sample one more (deeper) site beyond that point to ensure that you have correctly identified the maximum plant depth. This should be done for each set of points surrounding the deep portion of the lake. Along any N-S or E-W transect, sampling should continue for at least 2 points beyond the last site with plants. Some sites may not have any plants, even if the site is shallower than the maximum plant depth. For these sites, fill out the data sheet as usual (with no species identified). These sites will be included as sites as deep as, or shallower than, the maximum plant depth.

7. Collect voucher samples. Collect 2 samples of each species found on each lake. These samples must be pressed and dried according to the protocol in Appendix F. Send one prepared specimen to the local DNR office (who will pass them on to a University herbarium). Keep one specimen for the lake group as a reference for future plant identification. If the field team is unable to identify a plant, please try to get fresh plants to the local DNR lake management specialist as it is much easier to identify fresh plants than pressed plants. Be sure to let them know you are sending plants so that they can be processed promptly.

IV. Entering data on the spreadsheets and summary data

The APMstats123.xls Excel workbook has 5 spreadsheets:

a. READ ME, with a summary of all the spreadsheets included in the worksheet. The date records the most recent version.

b. Field Data, discussed above.

c. ENTRY, a data entry sheet for transferring field data to the computer spread sheet. You must transfer all of the information collected in the field to the ENTRY sheet. You should be able to copy the coordinates for the sampling points from the text file you uploaded onto the GPS unit and paste these into the entry sheet. There is a column for comments on the ENTRY sheet.

d. STATS, an automated statistics page that provides a summary of the plant data. The summary statistics of the plant survey will automatically appear in the STATS sheet of APMstats123.xls after data are entered in ENTRY.

e. Boat Survey, discussed above.

V. Where to Send Data

Send electronic copies of the ENTRY, STATS and Boat Survey to Jen Hauxwell (Jennifer.Hauxwell@dnr.state.wi.us).

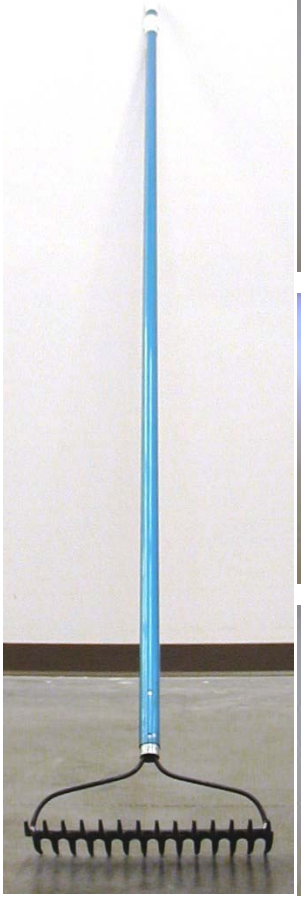
Rake Fullness Ratings

Rake fullness ratings are given from 1-3 for each species. Conditions of the ratings are described below:

Rating	Coverage	Description
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

Rake Construction

Pictures of a rake are shown below, with potential vendors of the components indicated. (These are not endorsements of specific vendors.)



Pole Sampler
The rake sampler is made from two rake heads welded together, measuring 13.8 inches (35 centimeters) long with 14 teeth on each side. This example purchased from Menards with wooden poles attached and subsequently removed).

The handle is 8 ft (2.4 meters) in length, and should include a telescoping extension that results in a total handle length (from tip of rake head to fully extended end) of 15 feet (4.6 meters). This example was purchased from a pool supply company in Madison, WI (Bachmann Pool & Spas).

Rope Sampler
A similar rake head should be constructed for the rope sampler. At the point where the pole would be attached, tie on a rope or anchor line of at least 40 ft in length. If desired, attach a 5 lb weight to the top of the rake (away from the tines) or thread it on the rake rope. This example has a length of steel tubing welded to the rake head to serve as a handle through which is strung ~45 ft of climbing rope.